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PHYSICS.—*Certain aspects of Henry's experiments on electromagnetic induction.*[1]

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(Communicated by L. H. ADAMS.)

I regard it as a great honor to be invited to give the first of a series of lectures before the Washington Philosophical Society, to be known as the Joseph Henry lectures, established in honor of the founder and the first President of the Society.

I think it is undoubtedly proper for me to choose as the topic of this first lecture one which is related to the life of Joseph Henry, partly because of the association of his name with the lectureship, but also because this year is recognized as the one hundredth anniversary of the discovery of the phenomena of electromagnetic induction, a discovery with which the name of Joseph Henry will always be associated.

This discovery of electromagnetic induction marked the beginning of the modern era of electricity and in fact of the modern era of physics, and it is therefore most fitting that a celebration of the centennial anniversary of the discovery should take place. Last month such a celebration was held in London at the Royal Institution, to commemorate the part Michael Faraday played in the discovery. Although he was anticipated in this by Joseph Henry, so far as both mutual induction and self induction are concerned, Faraday will always be regarded, properly I think, as their real discoverer because he was the first to publish the results of his investigations and pointed out at the time of his first announcement the possibility of making practical application of them. Joseph Henry, himself, although he deeply regretted the fact that he had delayed publication of his investigations, always gave

[1] An address delivered before the Philosophical Society of Washington on October 24, 1931. Received November 12, 1931.

full credit to Faraday and was scrupulously careful to refer to him as the discoverer. The newspapers, magazines and scientific periodicals have called attention repeatedly during the past two months to the work of Faraday and to his greatness as an experimenter and as a philosopher of nature. Rather scant notice has been given to the work of Joseph Henry, one writer saying that he "probably anticipated" Faraday; and my real reason for selecting the topic I have for this evening is my desire to impress upon all of you who listen to me the essential facts of Henry's great discoveries. Certainly whenever an American physicist hears the words, induced currents, the first thought that should come to his mind is "Joseph Henry discovered these."

It will indeed be superfluous for me to give a sketch of the life of Henry or to refer in detail to the long series of his brilliant investigagations in the varied fields of physics or to his great contributions to the scientific life of this country. Anyone who is interested in these matters should read the address by Professor William B. Taylor which was read before this society fifty-three years ago this month and which was published by the government in a volume devoted to the life and scientific work of Henry, and especially the excellent article by Professor Magie in the October number of *Reviews of Modern Physics*.

I intend to confine myself this evening to the question of induced electric currents and, even more narrowly, to the original experiments of Henry, calling attention particularly to the dates at which his discoveries were made. I must begin, however, by making as the background of my paper a statement concerning the scientific knowledge available at the time Henry began his experiments and also a description of Henry's environment, so that you may understand more clearly the stimulus which animated him and the difficulties under which he labored.

In 1819 Oersted made the discovery that an electric current flowing in a conductor exerted a force upon a magnet and this great event was, of course, followed at once by investigations all over Europe. In the following year Schweigger devised his multiplier consisting of an arrangement by which a magnetic needle came under the influence of several turns of wire, and thus perfected a rather sensitive instrument for the detection of an electric current. In this same year, 1820, Arago and Davy discovered independently that a steel needle placed axially inside a helix of wire became magnetized when an electric current was passed through the helix. In this experiment of Arago's the wire was

uncovered and was wrapped in a loose helix around a glass tube, the needle being placed inside this tube. In the same year also Ampère began his brilliant series of studies on the action of currents on magnets and of currents on currents, resulting in the discovery of phenomena which form the basis of electrodynamics. In these experiments Ampère used single turns of bare wire. In 1825 William Sturgeon of Woolwich, England really developed the electromagnet by winding uncovered wire around an iron bar, which was insulated from the wire, the iron bar itself being bent into the shape of a horseshoe so that an armature could be placed across its two ends. In this electromagnet Sturgeon used eighteen turns, loosely coiled. These were the essential facts concerning the relations between electricity and magnetism known to the scientific world at the time Henry began his studies.

In 1826 Joseph Henry was elected Professor of Mathematics and of Natural Philosophy at the Albany Academy. This was one of the outstanding High Schools of the State of New York and the work done there compared favorably with that characteristic of some of the colleges of that day. He was twenty-seven years old at the time of his appointment and his interests were already centered in the study of natural philosophy, his attention having been called to the subject when he was fifteen years old by the chance reading of a book which he had found left on a table by a man boarding with his mother. This book, Dr. G. Gregory's *Lectures on Experimental Philosophy, Astronomy and Chemistry*, made a great impression upon the boy's mind, and it is recorded that the owner gave it to him and that he kept it with him throughout his entire life. It aroused his intellectual curiosity and inspired him with a desire to answer questions dealing with nature. He set to work at once to perfect himself for this life of investigation, and after some years of study, teaching and tutoring, during which time he presented several papers before the local Scientific Society, the Albany Institute, he was chosen unanimously to fill the position I have mentioned. Albany at that time was a small city practically on the frontier, remote from centers of scholarship or of study, but the Albany Academy was a very worthy institution. It occupied a large building in the center of the city, consisting of classrooms and one good sized hall in its center, used for general purposes. There was no laboratory, of course, as such, and no apparatus of any kind; consequently Henry had to do everything with his own hands except so far as he could call upon a blacksmith to help. Schools in those days were rather serious-minded institutions and Henry was kept fully occupied with his classes

as long as the school was operating, which was for practically ten months of the year. The sessions began the first of September and during all the time Henry was professor in the Academy the only opportunity he had for experimental investigations was during the summer vacations, and practically for only one month, the last part of July and the first part of August. When the vacation began Henry would set up his apparatus in the main hall of the building and he could work with it until in August the time came for the building to be cleaned and gotten ready for the classes which met, as I have said, the first of September.

I must ask you to consider this situation and to contrast it with that of the investigators in Europe, especially of Faraday. Here was a man evidently full of ideas, evidently eager to add to knowledge and to test his theories by experiments; but he had no apparatus, he had no means to buy any even if it had been available and he had at his disposal only a few weeks of the year in which he could devote himself to what was really the purpose of his life. When one considers these circumstances it is extraordinary indeed that Henry should have been able to advance as far as he did.

Henry read with eagerness everything that was published in regard to the connection between electricity and magnetism and as soon as he became a professor at the Albany Academy he began to make plans for the continuation of the experimental work of which he had read. The first thing he planned to do, naturally, was to repeat the work of others so as to convince himself of its accuracy and to become more familiar with the phenomena. In thinking over the experiments done by others he believed that he could increase the sensitiveness of the apparatus and could magnify the forces by an extremely simple device, which apparently had not occurred to anyone else. This was to use coils of insulated wire in place of single turns, and in October, 1827 he demonstrated before the Albany Institute the various experiments of Ampère and others using coils and thus magnifying the effect greatly. In order to super-impose one layer of the coil upon another layer, thus forming a bobbin, it was obviously necessary to insulate the wire itself, which he did by wrapping the wire "with silk," as he says. I have heard from the family that "the silk" used by Henry in making some of his first coils was really a series of ribbons of silk obtained by the sacrifice on the part of his wife of her white silk petticoat. An electromagnet made by Joseph Henry and used in his experiments is still in existence, being treasured in the museum at Princeton University, and

one can still see the white silk ribbons used in its construction, so I believe the story I have heard is true.

One can hardly overestimate the importance of this device of Henry's. No one up to this time had thought apparently of using insulated wire coiled in layers, and immediately after Henry described his apparatus all the investigators of Europe adopted the idea. Faraday in his original apparatus, used when he made his discovery of electromagnetic induction, wound bare wire on an insulated iron ring, the separate coils being kept apart by winding between them a long twine, the separate layers being kept apart by pieces of non-conducting cloth. One cannot tell by reading Faraday's papers whether this idea was original with him or whether it was adopted after having seen Henry's published paper. As a matter of fact, in no one of Faraday's papers is there any reference to the experimental work of Joseph Henry.

Henry's first application of this new principle of coiling long wires into a number of layers was in the construction of a small electromagnet which he exhibited before the Albany Academy in June, 1828; and, having found how successful it was, he made another more powerful one the following year, which he exhibited in March, 1829. He then had a new idea in regard to the winding of magnets and in the latter part of the same year made one in which he had two independent windings over the whole length of the iron core, so that he could join these two in parallel. Then in order to make a magnet which could be used for many experimental purposes, in August, 1830 he wound one in a distinctly novel way, producing a magnet by far the most powerful then in existence. He wound the core of this magnet with nine separate coils, each coil occupying a space of about two inches. The terminals of each coil extended out from the side so that he was able to join the nine coils either in series or in parallel. This offered him a great variety of experimental possibilities. He investigated in connection with this magnet the effect of using a number of voltaic cells arranged in parallel or in series and he emphasized the effect of having the cells when in series joined with the coils of his magnet also in series and similarly the effect of having either one cell or all the cells in parallel joined with the coils of his magnet when these were in parallel. He made a study of what we would today call Ohm's law so far as the effect of the internal resistance of batteries is concerned and also performed many other experiments, some of which I will refer to later. All this was in August, 1830. In November of the same year he saw in

Brewster's Edinborough Journal an account of some work done by the Dutch physicist, Moll, in regard to electromagnets and thought it best to write an account of his work up to that time upon the same subject. This he did in November and submitted it for publication in *Silliman's Journal*. It was published in January, 1831 and was Henry's first scientific publication in a recognized scientific journal. It was characteristic of Henry for many years not to publish his results as soon as he had obtained them, but rather to wait until he had tested and investigated the various ideas which were in his mind on any one subject so that he would be convinced that he had exhausted the possibilities of that particular line of thought. This quality of his mind resulted naturally in the fact that so far as publication was concerned he was anticipated often and he was in several cases persuaded by his friends to write brief accounts of what he had done after the publication by others of their work.

I refer above to experiments which Henry made with his final form of magnet, and these he did not include in his paper in *Silliman's Journal*, which was confined simply to a description of his magnets. His reason for not publishing some of these experiments which were made in August, 1830 was because he intended to continue these further, and during August, 1831 he was very busy preparing some new apparatus one portion of which was a large reel containing a mile of wire and another was a much more powerful electromagnet. In a letter of November 6, 1831 he says that he had been making this apparatus "for some contemplated experiments in the identity of electricity and magnetism." In another letter he says that he had to stop his work on this new apparatus because the room in which he was working was wanted for the classes of the Academy. It is clear, therefore, that in August, 1831 he had been occupied with the construction of apparatus with the idea of continuing some of the work which he had begun in August, 1830 and which he had not thought to be sufficiently advanced to justify publication.

Immediately after the discovery of the fact that an electric current through a coil of wire would magnetize a piece of iron and in fact that a coil of wire carrying an electric current had magnetic properties, many investigators felt that there should be some way by which an electric current could be produced by means of a magnet and experiments of various kinds were tried. Among others, Michael Faraday of the Royal Institution, London, occupied himself with the problem for some

years and on August 29th, 1831 began a series of experiments which finally solved the problem. He reported the essential features of his experiments to the Royal Institution and also to the Royal Society and preliminary accounts were published in the spring of 1832. Henry saw these probably in June of that year and thought it best to publish at once his preliminary investigations on the same subject, so that the first published account of his work appeared in the July, 1832 number of *Silliman's Journal*. In this account he describes experiments on the production of electric currents by varying the magnetic field through a coil of wire and also an observation which he had made some years before concerning the spark which is produced when an electric circuit is broken. He noted further that these two phenomena were evidently due to the same fundamental cause. I shall describe later the details of these experiments, but I wish at this time to call attention to the probable dates at which they were performed. In view of what I have said above I do not think there can be any doubt but that his observations of induced electric currents due to a varying magnetic field were carried out in August, 1830 when he was working with his new magnet. In fact, he says explicitly that the observations were made by using this magnet. When he observed the spark produced at the breaking of a circuit and studied the effect on this spark of various forms of the circuit it is quite impossible to say. It certainly was an early observation and the date has been set by Joseph Henry's daughter, Miss Mary Henry, as in 1829. This is extremely probable and the claim, I think, is supported by various considerations. Miss Henry says that she often talked with her father concerning the early history of electromagnetic induction and that he always spoke as if he had discovered induced currents in 1830 and made his first observations of self induction in 1829. I think it is very reasonable to believe that it was his observation of the electric spark on breaking a circuit and certain other phenomena to which I shall refer later, these being made in August, 1829, that led him to undertake the experiments which culminated in the discovery of induced currents in August, 1830 after he had completed his new magnet. In any case he saw so much ahead of him in August, 1830 calling for the construction of new apparatus that he thought it best not to publish his preliminary studies, so that August, 1831 found him busy making the apparatus which he felt necessary to have available to continue his investigations. Then again, he was stopped in his work by the opening of the school session and probably

he would not have published any full account of his studies until after August, 1832 if it had not been for the fact that he saw that Faraday had already made some of the discoveries with which he was familiar as the result of his own investigations.

After Henry saw the brief notes concerning Faraday's work he took up the problem anew, repeating some of Faraday's work and extending his own, although the latter was very complete and convincing.

Having made his powerful electromagnet, which I have described above (early in the summer of 1830), he wound a coil of wire around the armature of the magnet and led the terminals of the wires to an instrument for indicating current. He noticed that when he turned on the magnetizing current there was immediately a fling of the galvanoscope needle and that when he broke the magnetizing current there was a fling in the opposite direction. He further observed that when he turned the magnetizing current off and detached the armature there was also a fling of the galvanoscope needle, the amount of which varied according to the distance he moved the armature. Finally, he observed that when the armature was in place on the magnet and he varied the magnetizing current there was also a fling. So he felt justified in drawing the conclusion that there was an instantaneous current in one or the other direction in a helix of copper wire surrounding a piece of soft iron accompanying every change in the magnetic intensity of the iron. No statement concerning the production of induced electric currents could be any clearer than this.

His observation of certain phenomena of self induction, probably made in 1829, was equally important. Having noticed this fact of the appearance of a spark which may have been and probably was a chance observation owing to some break in an electric circuit, he studied the effect of having the circuit consist of a short wire or a long one and also the effect of coiling a conductor into a spiral or helix, noting the increased effect when the latter was done.

We have seen that in the summer of 1831 Henry was busy making a new magnet and new apparatus for experimental purposes. In 1832 he was elected Professor of Natural Philosophy at the College of New Jersey, now Princeton, and he moved there with his family in November of that year. The first few years of his incumbency were occupied with the immediate duties of his chair and he did not have an opportunity to continue his studies until 1834. In November of that year Faraday published an account of his discovery of the phenomena of self induction and Henry's friends persuaded him that it was his duty to

publish at once an account of what he had done on the same subject up to that time. This he did. He gave an oral account of his work before the American Philosophical Society in Philadelphia at its meeting of January 16, 1835 and wrote a fuller account, which was published in *Silliman's Journal*. He had extended the observations to which I have referred above by investigating not alone the spark produced on breaking the circuit, but also the currents and the shock which accompanied the break. He had also studied the effect of introducing iron into a helix and had really made great progress. From this time on Henry worked fairly continuously and, apparently having learned his lesson in regard to publication, communicated his results as soon as he was convinced that they were definite. He had been elected a member of the American Philosophical Society in 1834 and thereafter he communicated his results to this Society and they were published in its *Transactions* or *Proceedings*.

He continued for some years his study of the phenomena of self induction and other effects of electromagnetic induction; in fact there was a constant series of publications on the subject till his election as Secretary of the Smithsonian Institution in December, 1846.

In one series of experiments he investigated the effect of a discharge of a Leyden jar through his primary coil in producing induced currents in neighboring conductors and was ultimately led to the proof that such a discharge was oscillatory. (Conviction that this was the character of the discharge had been expressed previously in 1827, by Savaray, but this fact was not known by Henry.) He was able to prove also that this inductive action produced by discharges through a primary conductor was felt at considerable distances, certainly as far as two hundred feet. This is the first experiment on record of electromagnetic waves (in 1842).

One of his most important studies dealt with the effect of introducing sheets of conductors between his primary and secondary coils (in 1838). One of the main interests in this study lies in the fact that Henry's observations were quite contrary to those announced by Faraday. Henry showed that the introduction of a plate of copper cut off completely the inductive action, whereas Faraday had found that there was no shielding effect. The explanation of the discrepancy, which Henry, himself, was able to make, lies in the fact that Henry's observations were on what we nowadays call electromotive force, whereas Faraday in his investigations was concerned with the quantity of

induced current. This fact emphasizes the difference in the experimental equipment of the two investigators. Henry had practically no measuring apparatus and had to content himself with such observations as sparks and the shocks received when discharges were passed through his body; Faraday, on the other hand, had a well equipped laboratory. It is extremely interesting as one reads the papers by the two great physicists to see how they express themselves without having the benefit of the knowledge which came when Ohm's law was known. I think of the two men Henry had perhaps a clearer understanding of the essential features of induced currents, but I could not give conclusive proof of this. Both men were aware of the fact that there was one quality of the current which depended upon the rate at which the magnetic field is changed, this being what determines the shock in the muscles and the distance at which a spark will occur in a broken circuit, and that there was another property of the current depending upon the total change in the field, which determined the fling of the galvanometer needle. The former was independent of the material of the conductor, while the latter varied with it. It was not, however, until the work of Lenz and of Neumann that all the difficulties were removed and all the phenomena expressed in one simple equation.

One interesting experiment of Henry's in this connection was to show that although there were differences in the shock produced in the secondary coil when the current was made or broken in the primary, there was no difference at all in the fling of the galvanometer needle. This observation led him to a very careful study of the phenomena associated with making and breaking a circuit.

The discrepancies between the observations of Henry and of Faraday, dependent upon the fact that the former was observing as a rule electromotive force while the latter was measuring the quantity of current, reminds one very much of the discrepancies which existed in the early history of mechanics, discrepancies which were only cleared up by the mathematical work of D'Alembert. Mechanics had its origin, as is known to you all, in the work of Galileo, Newton and Huyghens, and in the century that followed their first publications a controversy as to the proper measure of those agencies in nature which produce the changes in velocity of a body. One school of writers insisted that the proper measure of the effect of such agencies was to be found in the difference in the squares of the velocities of the body at the beginning and the end of the action. Another school insisted equally

vehemently that the effect should be measured by the difference in the velocity. If this dispute were stated in modern language it would be somewhat as follows: Is the effect to be measured by the change in the kinetic energy or by the change in the momentum? It was D'Alembert who first showed that neither one of them was the proper measure, because the change in the kinetic energy is equal to the product of the force by the distance through which the body moves under the action of the force, while the change in the momentum is equal to the product of the force by the time during which the body is under the action of the force. Or, it may be said, if one wishes to, that both schools were right and that they were looking at the two sides of the shield as in the ancient fable. Something of the same kind may be said in regard to work of Henry and Faraday. Their research work was absolutely trustworthy, but their interpretation of this could not be completely satisfactory until the work of Ohm was appreciated and until the mathematicians had completed their study.

I can add but little to what is well known concerning Henry's qualities as an investigator and administrator. As one reads the various papers contributed to the memorial volume devoted to his life, one is struck by the universal admiration for his broad philosophy, his accuracy of observation, his brilliant intuitions and his devotion to the cause of science in its widest interpretation. He was unselfish to a marked degree. He was not interested the faintest in personal advancement or in advancing claims for discoveries or inventions. His sole purposes in life were to interpret nature and to diffuse knowledge among men. Beyond any doubt he is the outstanding figure in the history of the scientific life of America.

GEOLOGY.—*Seven coastal terraces in the southeastern States.*[1] C. WYTHE COOKE, U. S. Geological Survey.

In two recent papers[2] I called attention to the horizontality of the shore lines that bound the marine Pleistocene terraces of the eastern and southeastern United States and interpreted it as due to the stabil-

[1] Received November 17, 1931. Published by permission of the Acting Director of the U. S. Geological Survey.

[2] C. WYTHE COOKE. *Pleistocene seashores.* This JOURNAL 20: 389–395. 1930. *Correlation of coastal terraces.* Jour. Geol. 38: 577–589. 1930.

ity of the land on which a fluctuating sea had cut its marks at various levels. The fluctuations of sea level were attributed primarily to the varying quantities of water contained in the waxing and waning continental ice caps, sea level having been low during times of greater glaciation and high when there was less ice. Under this hypothesis, the shore line of each coastal terrace was formed during an interglacial stage.

I also pointed out the obvious facts that fluctuations of sea level are not local but are world-wide and that contemporaneous beaches stand at nearly the same level on all lands that have not moved since the sea lay upon them but that the beaches may vary somewhat in altitude because of local differences of tidal range. As many lands have presumably remained rigid and undisturbed throughout Quaternary time, it may be possible to detect abandoned beaches along their margins at the same altitudes as those along the southeastern part of the United States. When they are found a ready means will be at hand to establish exact correlations between the interglacial Pleistocene deposits of the eastern United States and those of other continents. Anthropologists and archeologists may be able to date the stages in the evolution of man and his cultures in terms of an intercontinental chronology, and glacialists may eventually tie in the complex history of the advances and retreats of the ice sheets of North America with those of other lands.

In the papers cited I recognized only six Pleistocene shore lines at altitudes about 25, 65, 95, 160, 215, and 265 feet above the present sea level, but mentioned the possibility that there might be more than the six enumerated. The altitudes assigned to these shore lines were intended to indicate the approximate position of mean sea level when each terrace was formed, and were therefore purposely made a little lower than the highest water marks of the time, which presumably were produced by high tides and storms. In the present paper attention is called to a seventh shore line which was overlooked in earlier work, the altitudes of the beaches are revised (the average former high-water mark rather than former mean sea level being chosen although the datum of reference is present mean sea level), the distribution of each terrace in the southeastern States is sketched, and recommendations are made as to what name should be applied to each terrace. The altitudes of the seven shore lines now recognized and the preferred names of the terraces corresponding to them are as follows:

270 feet (82 meters), Brandywine terrace.
215 feet (66 meters), Coharie terrace.
170 feet (52 meters), Sunderland terrace.
100 feet (30 meters), Wicomico terrace.
70 feet (21 meters), Penholoway terrace.
42 feet (13 meters), Talbot terrace.
25 feet (8 meters), Pamlico terrace.

It should not be forgotten that points on a terrace are ordinarily lower than the corresponding shore line and may be almost as low as the next lower shore line. Thus, the Sunderland terrace (if no intermediate terraces have been overlooked) may range in altitude from 170 feet above sea level at its former shore line to 100 feet above sea level at its outer edge.

All of the terraces above listed are, in my opinion, recognizable in the eastern United States at least as far north as Maryland and are interpreted by me to indicate marine or estuarine shore lines throughout their extent. According to another interpretation recently published[3] marine terraces in the Potomac basin are recognized only below 100 feet elevation and all deposits above that level are considered to belong to an alluvial fan laid down on land by the Potomac River.

The Brandywine terrace.—The type locality of the Brandywine terrace may be considered to be the same as that of the Brandywine formation, about which there can be no question. Clark[4] wrote as follows: "The name Brandywine is proposed for this formation as the deposits are extensively and typically developed in the vicinity of Brandywine, Prince Georges County, Maryland . . . . Brandywine . . . . is located on the slightly-eroded surface of the old Brandywine terrace not far from the center of the largest tract still preserved intact. . . . . The formation attains its maximum thickness in the general area in which Brandywine is situated. No section of the formation is exposed at Brandywine since it is situated on the uneroded surface of the formation, but the adjacent ravines both to the east and west cut through the formation, exhibiting the gravels, sands, and loams characteristic of the formation."

[3] M. R. CAMPBELL. *Alluvial fan of Potomac River.* Geol. Soc. Am. Bull. 42: 182. 1931.

[4] W. B. CLARK. *The Brandywine formation of the Middle Atlantic Coastal Plain.* Am. Jour. Sci. (4th. ser.) 40: 499, 505. 1915.

As Clark included in the Brandywine formation some deposits that are now known to be older and others that are younger than those at Brandywine, the formation should be restricted so as to include only those gravels, sands and loams that were laid down in the Brandywine sea and in the contemporaneous estuaries and rivers. As the shore of the sea and estuaries during Brandywine time appears to stand about 270 feet above the present sea level, that altitude may be assumed to represent the upper limit of the Brandywine formation and the 270-foot contour line may be assumed to mark approximately the landward margin of the Brandywine terrace except where the land has been cut back by later erosion. If, however, a shore line between 233 feet (the altitude of Brandywine) and 270 feet should be discovered, the formation and terrace would need to be further restricted.

Several remnants of the Brandywine terrace in Virginia are shown on the map of Washington (D. C.) and vicinity, notably the ridge between Baileys Crossroads and Theological Seminary and along the Fairfax Road south of Back Lick Run. Part of the so-called "Lafayette" terrace of North Carolina represents the Brandywine. In the mapped parts of South Carolina and Georgia the Brandywine terrace is considerably dissected, but farther south in Georgia it is represented by large flat areas. The name "Hazlehurst" which I applied to it in 1925 should be discarded in favor of Brandywine, which has priority.

The Brandywine terrace does not appear on any published topographic maps of Florida because the areas mapped are too low, but it probably fringes the highlands of western Florida and of Dade County which rise above 270 feet.

The Coharie terrace.—The typical Coharie terrace[5] is crossed by Great Coharie Creek in Sampson County, North Carolina, and is shown on the Coharie quadrangle. The prevailing altitude of the plain in this region is between 180 and 190 feet, although it rises to 210 feet above sea level in the northwestern corner of the quadrangle. The shore of the Coharie sea does not cross the Coharie quadrangle, but is faintly shown in the western part of the Four Oaks quadrangle, which adjoins it on the north, where there is a rise from 215 feet to 230 feet within a quarter of a mile. The shore is more plainly visible on the Orangeburg (South Carolina) quadrangle, where a scarp rises from about 215 feet to 270 feet in half a mile. Although these slopes

[5] L. W. STEPHENSON. North Carolina Geol. Survey 3: 273. 1912. The Coharie terrace, as mapped by Stephenson, included a large part of the Brandywine.

would appear insignificant in a hilly country, they are much steeper than the normal slope of the undissected terrace plain.

The "Claxton" terrace of Georgia, as shown on the Claxton quadrangle, stands at the same altitude as the typical Coharie, and is evidently the same terrace. The name Coharie has many years' priority. Part of a large outlier of Coharie terrace (an island in the Sunderland sea) is shown on the Arredondo quadrangle north and northwest of Gainesville, Fla. In Virginia, the Coharie terrace is considerably dissected, but many flat patches of it remain, such as that 2 miles east of Fredericksburg (Stafford quadrangle and map of Fredericksburg and vicinity) and at Arlington (map of Washington and vicinity). In the District of Columbia, the Coharie terrace (estuarine facies) is well developed at Meridian Hill Park and in the Mount Pleasant section of Washington. In Maryland, the uplands in the southern part of the Brandywine quadrangle are part of the Coharie terrace.

The Sunderland terrace.—The name of the Sunderland terrace is derived from the hamlet of Sunderland, Calvert County, Maryland (Prince Frederick quadrangle). This place is not very suitable for a type locality, for it appears to lie between two outliers of the Coharie terrace, but the Sunderland terrace is further defined by Shattuck[6] as being limited by an ancient sea cliff at Charlotte Hall (Wicomico quadrangle), the foot of which he said is 170 feet above sea level. This definition is quite satisfactory. However, in later work[7] Shattuck included in the Sunderland much that falls within the Coharie and other terraces as now defined, with the result that the surface and the shore line of the composite Sunderland terrace appeared to be warped. The name Sunderland should be restricted to the terrace that is bounded by the shore line at or near 170 feet above sea level.

The shore of the Sunderland sea appears to have lain against or near the crystalline rocks of the Piedmont from Wilmington, Del., to Baltimore; thence it trended southward to the vicinity of Mechanicsville, St. Marys County, Md., lying several miles west of Patuxent River south of Bowie. There was a wide embayment up the Potomac Valley to Washington. In Virginia, the shore gradually approached the Piedmont, which it reached near Richmond and followed to the North Carolina line. The shore can be traced across the Kenly (North Carolina) quadrangle at an altitude apparently a little above 170 feet,

[6] G. B. SHATTUCK. Am. Geol. 28: 102–103. 1901.
[7] Maryland Geol. Survey. Pliocene and Pleistocene. 1906.

although the large contour interval and the lack of detail in the map do not permit one to locate it very accurately. In the mapped part of South Carolina, the shore is rather faint, but it can be traced at an altitude between 170 and 175 feet above sea level from the south fork of Edisto River near Bamberg past Allendale to the former estuary of Savannah River (Bamberg, Olar, Allendale, and Peeples quadrangles). In Georgia, the Sunderland terrace has been called the "Okefenokee" plain or terrace, but the name Sunderland has priority.

The Wicomico terrace.—Wicomico River in St. Marys and Charles counties, Maryland, suggested the name of the Wicomico terrace. According to Shattuck[8] in southern Maryland the base lies about 40 or 50 feet, and the top, where it borders its ancient sea cliff, about 90 feet above sea level. The only area within these limits in the neighborhood of Wicomico River shown on the much-generalized map of the Wicomico quadrangle is about 1 square mile southwest of Cooksey that lies between the 80 and the 100-foot contour lines. This area may be regarded as the type locality of the Wicomico terrace.

Ninety feet appears to be somewhat lower than the Wicomico shore line. Even 95 feet, which I assigned to the Wicomico in a recent paper, is a little too low. One hundred feet (30 meters) above sea level is generally considered as the upper limit of the Wicomico, and that altitude appears to be about right.

In Maryland, the Wicomico terrace is best developed on the Eastern Shore, where it forms the crest of the divide in Kent and Queen Anne counties, but strips of it are found along most of the estuaries west of Chesapeake Bay. The Capitol at Washington is built on it and Capitol Hill was mentioned by Shattuck as an example of the terrace. In Virginia, the Wicomico seashore followed the Surry scarp,[9] the foot of which lies about 100 feet about sea level (Surry and Ivor quadrangles), but estuarine reentrants of the terrace extend to the Fall Line along some of the streams. In North Carolina, part of the shore line is shown on the Falkland quadrangle south of Fieldsboro at an altitude of about 100 feet. It shows on the Manning and Pineland quadrangles (South Carolina) at the same level. On the Glennville (Georgia) quadrangle, the Wicomico shore can be traced along or near the 100-foot contour line southward for two-thirds the length of the map and

[8] G. B. SHATTUCK. Am. Geol. 28: 103. 1901.

[9] C. K. WENTWORTH. *Sand and gravel resources of the Coastal Plain of Virginia.* Virginia Geol. Survey Bull. 32: 55. 1930.

westward up the former seven-mile-wide estuary of the Altamaha River. In Florida, the Wicomico terrace, called "Newberry" by Matson, covers much of the Cambon quadrangle. Its shore lay along Trail Ridge on the adjoining Macclenny quadrangle and on the Lawtey quadrangle. Here, too, the altitude of the shore line is very close to 100 feet above sea level.

The Penholoway terrace.—The type locality of the Penholoway terrace is shown on the Hortense (Georgia) quadrangle.[10] This area lay back of a low barrier island on which Browntown and Winslow (Everett City quadrangle) stand and apparently was partly covered by tidal marshes, to judge from the pattern of the present drainage. High tides reached 70 feet above present sea level or possibly a foot or two higher. Seventy feet (21 meters) may be taken as the altitude of the shore of the Penholoway sea.

In Florida, a terrace standing within the limits of altitude of the Penholoway and probably equivalent to it has been called by Matson the "Tsala Apopka" terrace, but its type locality shows so much evidence of underground solution that the position of its shore line is problematical. The name Penholoway is therefore preferred although Tsala Apopka has priority.

The shore of the Penholoway sea can be easily traced at an altitude of about 70 feet across the Walterboro (South Carolina) quadrangle. Summerville and Pinopolis are built on a long spit or island that separated the Penholoway sea from the mainland. Ridgeville stands on a barlike island at the mouth of the bay back of it (Summerville and Ridgeville quadrangles). The seashore of the Penholoway terrace forms the southern part of the Kinston (North Carolina) quadrangle. In Virginia most of the seaward-facing part of the Penholoway terrace has been destroyed, but there are a few areas (notably south of Yorktown) which lie within its altitudes. Several remnants of the estuarine part of the Penholoway terrace border Potomac River in Arlington County, Virginia. College Park, Md., (map of Washington and vicinity) is built near the head of a Penholoway estuary. A ridge of clay that rises to an altitude of about 70 feet above sea level near the Mount Vernon Memorial Highway near Fort Hunt, Va., (Indian Head quadrangle) is interpreted as having been deposited during Penholoway

[10] C. WYTHE COOKE. *Physical geography of Georgia.* Georgia Geol. Survey Bull. 42: 24. 1925.

time by the Potomac estuary across the entrace to an old drowned meander curve cut by the Potomac River at some stage of Pliocene time.[11]

The Talbot terrace.—According to the original definition by Shattuck,[12] the 45-foot contour line marks the shore of the Talbot sea. As the actual shore line seems to be three or four feet lower than this, the altitude adopted in this paper is 42 feet, or 13 meters. The name is taken from Talbot County, Maryland. Shattuck included in the Talbot not only the Talbot terrace as here restricted, but everything between its shore and the Recent terrace that is now forming. Stephenson, in describing the Pleistocene deposits of North Carolina, divided the composite Talbot terrace into two parts, an upper "Chowan" terrace, which has the same shore line[13] as the typical Talbot, and a lower Pamlico terrace. It seems preferable to retain the name Talbot for the upper terrace and to discard the newer name "Chowan."

In Delaware and Maryland the ocean extended inland 12 or 15 miles beyond the present seashore during Talbot time. A low seaward-facing scarp above the 40-foot contour line on the Pittsville quadrangle shows its former margin. Elsewhere in Maryland, including Talbot County, the Talbot terrace was covered by Chesapeake Bay and its tributary estuaries. In Virginia, most of the seaward-facing part of the Talbot terrace has been destroyed, but the terrace is developed along many of the estuaries. The foot of an unusually fresh-looking eastward-trending scarp facing the James in the southeastern part of the Toano quadrangle a quarter of a mile north of B. M. 22 stands 41 feet above sea level. The sharpness of this scarp may have been accentuated by artificial grading.

In the mapped parts of South Carolina little of the original shore of the Talbot sea remains, although there were many islands of Talbot terrace in the succeeding Pamlico sea. In the *Physical geography of Georgia*, I pointed out[14] what is probably a remnant of the Talbot terrace between Hinesville and Canoochee River (Hinesville quadrangle) but interpreted it as a bench cut while the sea stood at a higher level.

[11] Wentworth (op. cit., page 77) interprets this oxbow as having been cut off and partly silted up in late Talbot time.

[12] G. B. SHATTUCK. Am. Geol. 28: 104. 1901.

[13] Stephenson did not define the "Chowan" terrace by reference to a shore line although he states (op. cit., page 283) that "the surface of the [Chowan] formation forms a plain which slopes up from elevations of about 25 to 40 feet above sea level along its eastern margin to elevations of about 50 feet along the foot of the escarpment separating it from the Wicomico plain above."

[14] Georgia Geol. Survey Bull. 42: 32. 1925.

The Talbot shore line is better shown along the East Coast of Florida, where it follows the 40-foot contour line from the forks of Black Creek on the Middleburg quadrangle southeastwardly across the southwestern corner of the Orange Park quadrangle. It is even more conspicuous on the Interlachen quadrangle, at the same altitude. Leverett[15] has traced this shore line down the eastern side of the Peninsula at an altitude of about 40 feet and referred it to the "Pensacola" terrace.

The Pamlico terrace.—The name Pamlico is derived from Pamlico Sound in eastern North Carolina, away from whose shores the Pamlico terrace extends as broad, nearly level stretches of lowland. The plain is also present on both sides of Pamlico River and covers the greater part of Pamlico County.[16] According to Stephenson, the terrace nowhere in North Carolina is higher than 25 feet above sea level. The Pamlico terrace may therefore be defined as the terrace having a shore line approximately 25 feet above sea level.

In Maryland the Pamlico seashore lay near the present Atlantic coast. Traces of it can be seen on the Snow Hill quadrangle. The estuarine facies of the terrace borders Chesapeake Bay from a few miles below Havre de Grace to Baltimore and covers a broad expanse on the Eastern Shore below Chestertown.

From the North Carolina line almost to Charleston, S. C., the shore of the Pamlico sea appears to have been cuspate and almost continuous, but from Charleston to Savannah there were many irregular islands like the Sea Islands of today.

In Georgia the Pamlico shore consists of two broad cusps broken by several bays and inlets. Almost everywhere in the area covered by topographic maps it is marked by a moderately high scarp, the foot of which lies about 25 feet above sea level. The terrace was excellently described by Otto Veatch[17] under the name "Satilla coastal lowland or Satilla plain" in a book which bears a date of publication a year earlier than that of Stephenson's description of the Pamlico although the letter of transmittal of the North Carolina report is dated four months earlier than that of the Georgia report. The name Pamlico is preferred because it has gained wider acceptance than "Satilla."

In eastern Florida the Pamlico terrace is backed by a scarp whose

[15] FRANK LEVERETT. *The Pensacola terrace and associated beaches and bars in Florida.* Florida Geol. Survey Bull. 7: 9–17. 1931.

[16] L. W. STEPHENSON. North Carolina Geol. Survey 3: 286. 1912.

[17] OTTO VEATCH. Georgia Geol. Survey Bull. 26: 36–38. 1911.

base lies below the 30-foot and above the 20-foot contour lines on the Boulogne, Hilliard, Cambon, Orange Park and Palatka quadrangles. In western Florida it stands at the same altitude on the War Department's fire-control map of Pensacola. Leverett[18] places the height of the "Pensacola" sea at Pensacola about 25 feet above present sea level.

Matson[19] described the "Pensacola terrace" as "a broad plain, rising less than 40 feet above sea level, and apparently including two divisions, one being less than 20 feet above, and the other from 20 to 40 feet above sea level." The lower of these two divisions is the Pamlico terrace; the upper is the Talbot. Frank Leverett, in searching for evidence of deformation of the "Pensacola" shore line,[20] overlooked the shore line of the lower of these two divisions in the east and the shore line of the upper of the two in the west. Therefore, in correlating the 40-foot (Talbot) shore in eastern Florida with the 25-foot (Pamlico) shore at Pensacola, he finds a gentle slope toward the west which he ascribes to tilt due to the increasing weight of the delta of Mississippi River. As further indication of this downwarp he says: "In the vicinity of Baton Rouge, on the east side of the Mississippi, the base of a scarp is down to about 15 feet." The foot of the scarp to which he referred, which is the one adjacent to Bayou Fountain on the Baton Rouge, La., quadrangle, slopes southeastward from about 30 feet at Baton Rouge to an altitude below 10 feet at the edge of the quadrangle, and apparently closely approaches sea level in the unmapped area farther east. It seems to have been the Recent shore of the Gulf before the Mississippi Delta was built up in front of it. The slope is that of the surface of the delta and is not due to tilting. Another scarp near Baton Rouge, shown by the closeness of the 40- and 50-foot contour lines, may mark either the Pamlico or the Talbot shores, or possibly both, for the Mississippi River is able to deposit sediment upon both the Pamlico and the Talbot terraces (raising them above their natural level) because high water at Baton Rouge, according to the map, is 41 feet above sea level.

No topographic maps showing the shores of Pamlico Sound have been published. The Belhaven quadrangle, however, which lies only a few miles north of Pamlico River, includes a large area of Pamlico

[18] FRANK LEVERETT. Florida Geol. Survey Bull. 7: 24. 1931.

[19] G. C. MATSON. *Geology and ground waters of Florida.* U. S. Geol. Survey Water-Supply Paper 319: 34. 1913.

[20] FRANK LEVERETT. Op. cit., pp. 26–29.

terrace and shows a short stretch of its shore line in the northwestern corner at an altitude of very nearly 25 feet. The Pamlico shore line can be easily traced across the Edenton, Beckford, and Suffolk quadrangles into Virginia, where it lies at the foot of the Suffolk Scarp.

Wentworth[21] has recently proposed to substitute for the Pamlico terrace of Virginia two terraces, an upper, which he calls the "Dismal Swamp" terrace, and a lower or "Princess Anne" terrace. If a marine terrace be defined by reference to the shore line of the tidal waters in which it was formed, it can not be divided, for a terrace can have only one shore line, although its supposed width may be restricted by the discovery of another shore line within the areal limits that had been assigned to it. As the "Dismal Swamp" terrace has identically the same shore line as the Pamlico,[22] the name Pamlico, which has many years priority, should be retained. The "Princess Anne" terrace was separated from the "Dismal Swamp" because of the presence of a low scarp above 12 feet in the neighborhood of Norfolk and elsewhere in Virginia. Although no one can dispute the existence of this scarp, for it is plainly shown on the Cape Henry quadrangle, opinions may differ as to whether it is really a sea cliff formed at a stage of the sea about 12 feet above the present sea level. The evidence at present appears to be inconclusive.

BOTANY.—*A crown-rot of hollyhocks caused by* Phytophthora megasperma *n. sp.*[1] CHARLES DRECHSLER, U. S. Department of Agriculture.

On May 15, 1931, a specimen of diseased hollyhock, *Althaea rosea* Cav., from a garden in the District of Columbia and reported to be illustrative of a trouble that had led to the loss of other plants in the same plot, was submitted to the writer for examination. Additional specimens were received during the ensuing two weeks. Early in June, perhaps because of the advent of drier weather conditions, but more probably because all the diseased plants had by that time succumbed, the destruction came to a halt in the garden referred to, though on June 5 a dying specimen from a small experimental planting

[21] C. K. WENTWORTH. Virginia Geol. Survey Bull. 32. 1930.
[22] C. K. WENTWORTH. Op cit., pp. 67–69.
[1] Received November 16, 1931

Fig. 1. A.—Hollyhock plant affected with crown-rot, as collected in Washington, D. C. showing decay throughout short over-wintered stem and in the discolored proximal portions of the fleshy roots, $\times\frac{2}{3}$. B.—Longitudinal section of hollyhock crown attacked by *Phytophthora megasperma*, showing sharp line of demarcation between decayed and healthy parts at bases of new shoots, $\times\frac{2}{3}$. Photographed by Lillian A. Guernsey.

of hollyhocks at Arlington Experiment Farm, Rosslyn, Va., was found to be affected with the same disease. While definite information as to the distribution of the malady is not available, there is reason to believe that it is fairly widespread, a grower in the vicinity of Racine, Wis., for example, stating that he had lost his entire planting of hollyhocks during the early part of June 1931, the destruction evidently having taken precisely the same course as was observed in the District of Columbia.

As the seat of the malady is very largely in the underground parts (fig. 1, A), the trouble makes itself manifest at the beginning sometimes through poor growth of the new shoots, but in other instances, as notably in the specimen at Arlington Experiment Farm, a dozen robust shoots between 1.5 and 2.0 meters high may be produced before any sign of abnormality is noticeable. Ordinarily no premonitory changes in coloration or turgidity of leaves or stalks are apparent when one after another the shoots fall to the ground, where they soon wither and die. In the course of a few days the entire aerial growth from a well developed crown may be killed. The manner of destruction thus shows a strong similarity to that pertaining to the foot-rot of various species of *Lilium* by the fungus generally designated as *Phytophthora cactorum* (Leb. & Cohn) Schroet., or to the foot-rot of rhubarb caused by *P. parasitica* Dast.

When the overwintered underground parts of a dying plant are examined, the short stem is usually found to be completely involved in a decay that extends downward into many if not into all of the large fleshy roots, often for distances of from 5 to 10 cm. and sometimes for distances of from 15 to 20 cm. Outwardly the decay is evidenced in a buff or sepia or darker brown discoloration, while internally the tissues, in addition to being more or less discolored, are softened to such a degree that the fibrous and woody elements are readily separated into longitudinal shreds. The decay is found usually to extend only a very short distance from the overwintered stem into the new shoots, the line of demarcation between diseased and healthy tissues being here rather sharply marked by a darkly discolored marginal zone (fig. 1, B). Apparently the shoots obtain water for a considerable period through the vascular elements of the completely killed overwintered parent stem, and fall to the ground only when the supporting tissues are weakened mechanically in such measure as no longer to be capable of supporting the weight of the aerial structures.

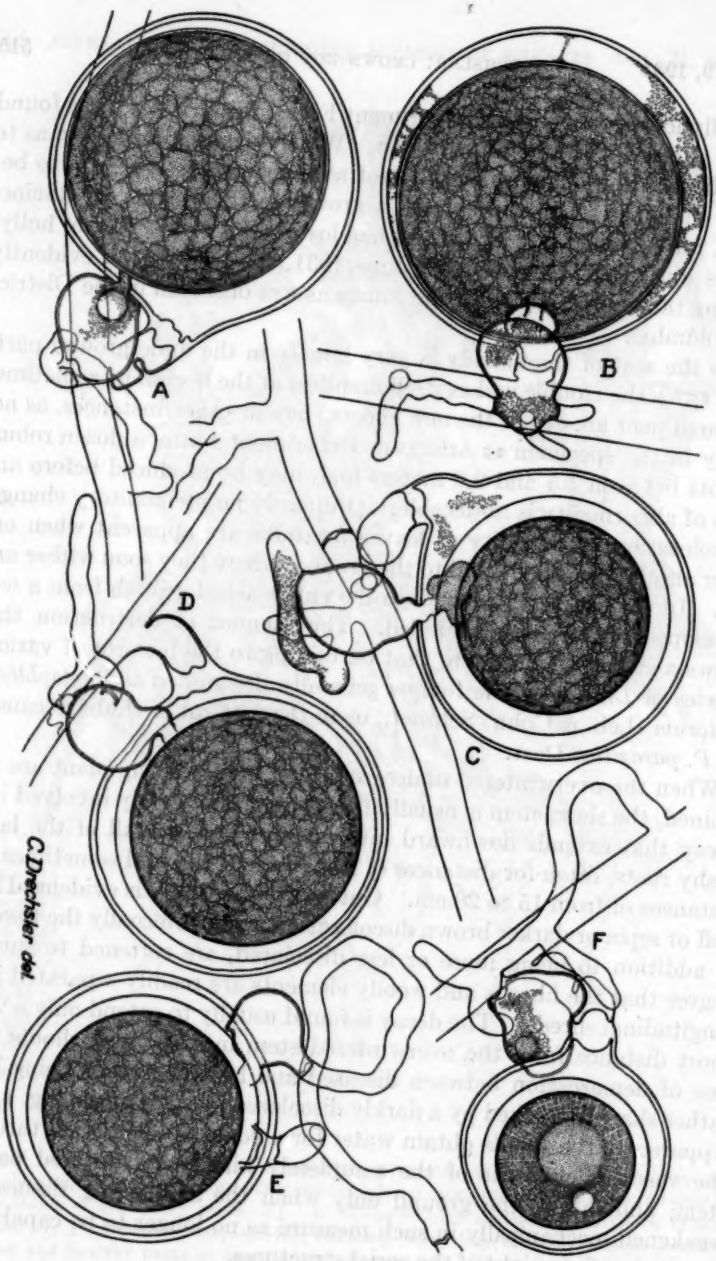

Fig. 2. Sexual apparatus of *Phytophthora megasperma*, drawn with camera lucida, ×1000.

In the greater bulk of the decaying tissues of the diseased hollyhock plants examined was found a moderate quantity of intercellular mycelium, which being usually devoid of protoplasmic contents, could not usually be made to yield new growth. New growth and subsequently pure cultures on artificial media were obtained fairly readily from pieces of newly invaded tissue from the margins of the diseased parts by employing the method set forth in an earlier paper (4), and with very satisfactory regularity when the washing of the infected material was continued until the gelatinous substance oozing in extraordinary quantity from the irrigated hollyhock tissue had been largely removed.

The fungus thus obtained displays in its mycelium the vegetative features generally associated with species of *Phytophthora*. Its staring, openly branching habit and the substantial appearance of the granular contents of its hyphae at once indicate a member of that genus rather than of the related genus *Pythium*. As in many other species of *Phytophthora* and, indeed, in various species of *Pythium*, septa make their appearance in the originally continuous hyphae with the withdrawal of the granular contents. In completely evacuated mycelium the rather thick cross-walls are present usually in considerable number.

A high degree of distinctiveness attaches, however, to the sexual apparatus, which is produced promptly and abundantly on nearly all substrata ordinarily employed (figs. 2–4). Aside from its ready production, the sexual apparatus is distinguished by the unusually large dimensions of oogonium and oospore. Thus 200 oogonia produced on maize-meal agar plates and chosen at random 10 to 15 days after planting, yielded measurements of diameters distributed according to values expressed to the nearest micron as follows: 33μ, 1; 34μ, 1; 37μ, 1; 39μ, 2; 40μ, 3; 41μ, 5; 43μ, 6; 44μ, 7; 45μ, 19; 46μ, 24; 47μ, 28; 48μ, 19; 49μ, 27; 50μ, 24; 51μ, 17; 52μ, 8; 53μ, 3; 54μ, 2; 56μ, 2; 57μ, 1. Measurements of the diameters of the 200 oospores contained within these oogonia yielded values distributed as follows: 26μ, 1; 28μ, 1; 30μ, 1; 32μ, 1; 33μ, 2; 34μ, 3; 36μ, 2; 37μ, 6; 38μ, 2; 39μ, 17; 40μ, 32; 41μ, 26; 42μ, 26; 43μ, 30; 44μ, 22; 45μ, 13; 46μ, 8; 47μ, 5; 49μ, 1; 52μ, 1. These values from which averages for diameter of oogonium and diameter of oospore of 47.4μ and 41.4μ respectively were computed, may presumably be regarded as fairly representative of the species, having been obtained from material in which the bodies in question were present

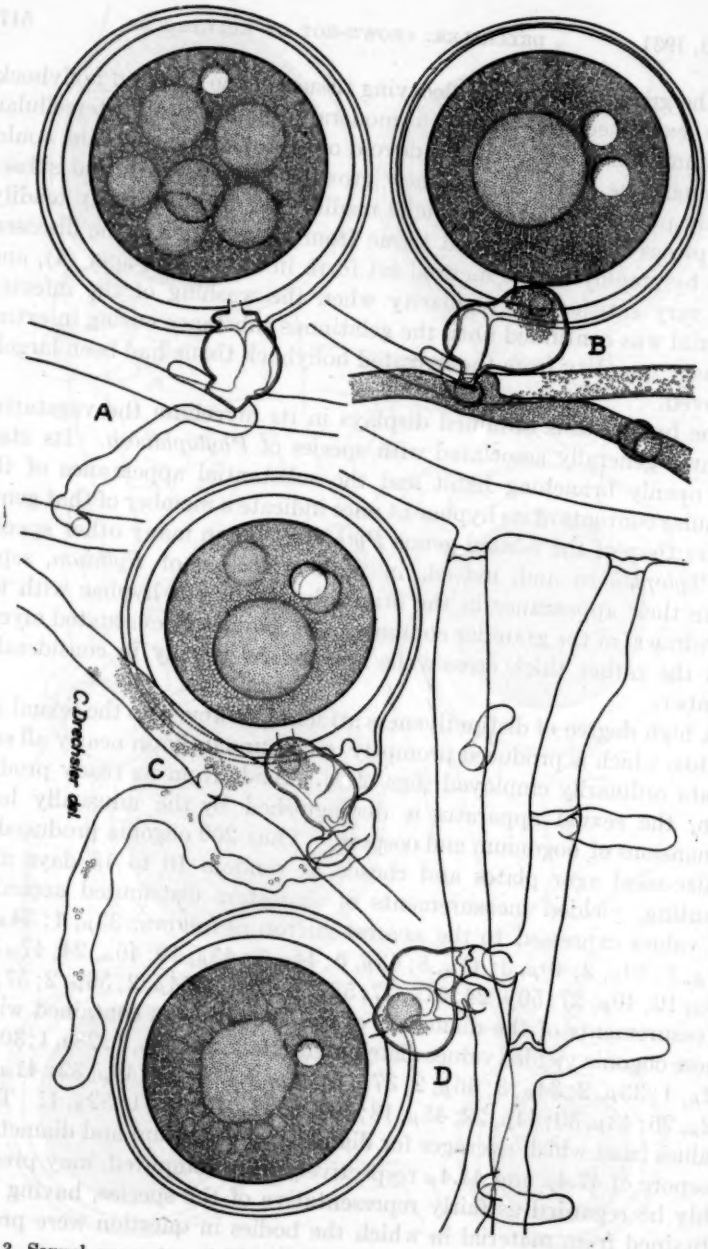

Fig. 3. Sexual apparatus of *Phytophthora megasperma* drawn with camera lucida, ×1000.

in large number and showed practically no tendency toward degeneration. The oospores in substantially all cases showed the structure normal for the stage of maturity in which they were found. Naturally more extreme values not included in the ranges found in the course of the random selections came under observation. Thus in the sex apparatus shown in Figure 4, E, among the smallest seen in an irrigated lima-bean agar preparation, in which somewhat smaller dimensions are wont to prevail then in dry maize-meal agar plate cultures, the oogonium measures only 16μ in diameter, while the oospore measures only 11μ; and again the very largest oogonium seen in any maize-meal agar culture was found to measure 61μ in diameter, and contained an oospore 54μ in diameter.

The pertinent literature contains few records of oogonia and oospores equalling or closely approaching in size those of the hollyhock parasite. In a recently published comparative study of the genus *Phytophthora*, Tucker (9) states that the oogonia and oospores of *P. erythroseptica* Pethyb. with average diameters of 36.3μ and 31.4μ respectively, and hence fully 10μ smaller in these dimensions than the hollyhock fungus, exceed in size those of any congeneric form, and held this superiority in size to be diagnostic for that species. In this connection it must be mentioned that Tucker reports that on transferring sterile mycelium of *P. erythroseptica* to Petri's mineral solution he found after one week a few large oogonia measuring 30.1 to 64.3μ (average 45.1μ) in diameter. As, however, oospores were not observed in these oogonia there were, indeed, excellent grounds for not regarding the large structures as representative of the species. Somewhat similarly disturbing considerations pertain to Petri's report (7) of the production of oogonia varying in diameter from 57 to 62μ and oospores "non ancora ben differenziate" measuring between 50 and 56μ by *P. cambivora* (Petri) Buism. grown on carrot-agar acidulated with malic acid, when previously (6) oospores of the chestnut parasite in the tissues of the diseased host had been found to measure only 20 to 27μ. Ashby (2) more recently reported the discovery of several oogonia and oospores in a pure culture of *P. cambivora*, which with respect to size more nearly approximated those of the hollyhock parasite. It is to be noted that whereas the antheridia of both *P. erythrospetica* and *P. cambivora* developing in pure culture have always been found to be of the amphigynous type, those of the hollyhock fungus are predominantly paragynous.

A really close approximation to the hollyhock parasite in size of oogonium and oospore is to be inferred from Alcock's summary (1) of the morphological features of the fungus held by her to be responsible for the "Lanarkshire strawberry disease" prevalent of late years in Scotland and England: "Oogonia average about 46μ to 47μ in diameter; oospores average about 33μ to 47μ diameter; oospore wall about 4μ thick; sporangia about 50μ by 30μ." Antheridia of the amphigynous type were stated to have been made out in the cells of the host in a few instances, failure to obtain the fungus in pure culture having precluded more complete observations of the sexual apparatus. According to a later note (3) of somewhat indefinite authorship, presumably the same parasite is "characterized by a large sporangium, by oospores of the two types and as far as has been ascertained is similar to *Phythophthora cinnamomi*." It is not certain whether the latter quotation is to be interpreted as implying that the strawberry parasite produces large globose resting bodies of the type described by Rands (8) for his *P. cinnamomi*; but assuredly no bodies of such type have ever been seen in cultures of the fungus isolated from diseased hollyhocks.

As has been mentioned the antheridia of the hollyhock fungus are predominantly paragynous. In plate cultures of maize-meal agar approximately 99 out of every hundred sexual units exhibit a paragynous relationship of the male organ (figs. 2, A-F; 3, A-D; 4, A-C), the amphigynous relationship occurring only rather rarely. On irrigated lima-bean agar preparations useful in the study of asexual reproduction the proportion of amphigynous antheridia (fig. 4, D-F) is much larger, varying often between 25 and 35 in every hundred. The fungus is very obviously homothallic, for in many instances when it is neither too remote nor leads into one of the knotted hyphal tangles present here and there, the mycelial connection between antheridium and oogonium may be readily traced. In some cases (figs. 2, D; 4, C) the combined lengths of antheridial branch, oogonial stalk and intervening portion of hypha is not in excess of 40μ. The usual somewhat irregularly orbicular or broadly elliptical shape of the antheridium is sometimes modified by the presence of a distal protuberance or lobe (figs. 2, B, C, D; 4, B) by which contact with the oogonium is established.

In its asexual reproduction the hollyhock parasite is rather similar to *Phytophthora cryptogea* Pethyb. & Laff., *P. cinnamomi* and *P. cambivora*. The sporangium is as a rule ovoid (fig. 5, A-F) but frequently the development of a distal lobe or protuberance (fig. 5, K, L, N, O) brings

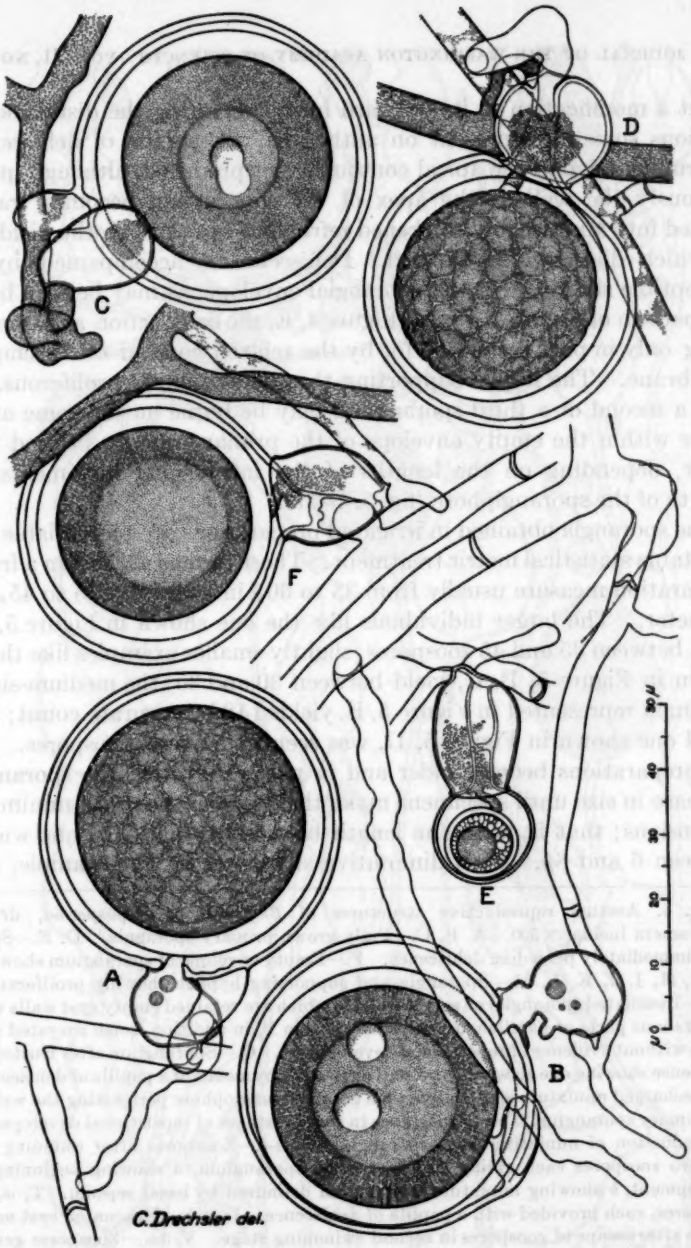

Fig. 4. Sexual apparatus of *Phytophthora megasperma* drawn with camera lucida, ×1000.

about a modification in its outward form suggesting the distal modifications sometimes present on antheridia. A papilla of dehiscence protruding beyond the apical contour is not produced, although quite obviously the wall at the apex of the sporangium becomes transformed into a noticeably thickened refringent cap through the yielding of which discharge is effected. Dehiscence is accompanied by a perceptible shrinkage of the sporangial envelope, as may be seen by a comparison of Figure 4, F with Figure 4, E, the contraction apparently being only in part accounted for by the relaxed contour of the empty membrane. The hypha supporting the sporangium is proliferous, so that a second or a third sporangium may be borne on the same axis, either within the empty envelope of the primary one, or beyond the latter, depending on the lengths of the intervening increments of growth of the sporangiphore (fig. 5, G-M).

The sporangia obtained in irrigated preparations are too variable for profitable statistical metric treatment. Those formed earliest in a fresh preparation measure usually from 35 to 60μ in length by 25 to 45μ in diameter. The larger individuals like the one shown in Figure 5, A, yield between 35 and 45 zoospores; slightly smaller examples like those shown in Figure 5, B, C, yield between 30 and 35; the medium-sized specimen represented in Figure 5, E, yielded 18 by accurate count; the small one shown in Figure 5, D, was seen to deliver 6 zoospores. As the preparations become older and in part exhausted, the sporangia decrease in size until specimens make their appearance with minimum dimensions; that is, with the length between 15 and 20μ, and width between 6 and 8μ. Such diminutive structures as, for example, the

Fig. 5. Asexual reproductive structures of *Phytophthora megasperma*, drawn with camera lucida, ×500. A, B, C.—Fully grown primary sporagnia. D. E.—Sporangia immediately preceding dehiscence. F.—Empty envelope of sporangium shown in E. G, H, I, J, K, L, M.—Sporangia and supporting hyphae showing proliferation. O, P.—Evacuated sporangial envelopes within which are retained empty cyst walls with membranous parts of papillae of dehiscence, and in P, in addition, some encysted zoospores without evidence of repetitional development. Q.—Sporangium after frustrated dehiscence showing one zoospore cyst wall evacuated by means of a papilla of dehiscence, one discharged miniature sporangium on a germ sporangiophore perforating the wall of the primary sporangium, and 10 zoospores in various stages of repetitional development by production of miniature germ sporangia. R, *a-i*.—Zoospores after rounding up. S.—Two zoospores each giving rise to a germ sporangium, *a* showing beginning of development, *b* showing miniature sporangium delimited by basal septum. T, *a-f*.—Zoospores, each provided with a papilla of dehiscence. U, *a-h*.—Evacuated cyst membranes after escape of zoospores in second swimming stage. V, *a-c*.—Zoospores germinating by vegetative germ tubes. W.—A zoospore in motile stage.

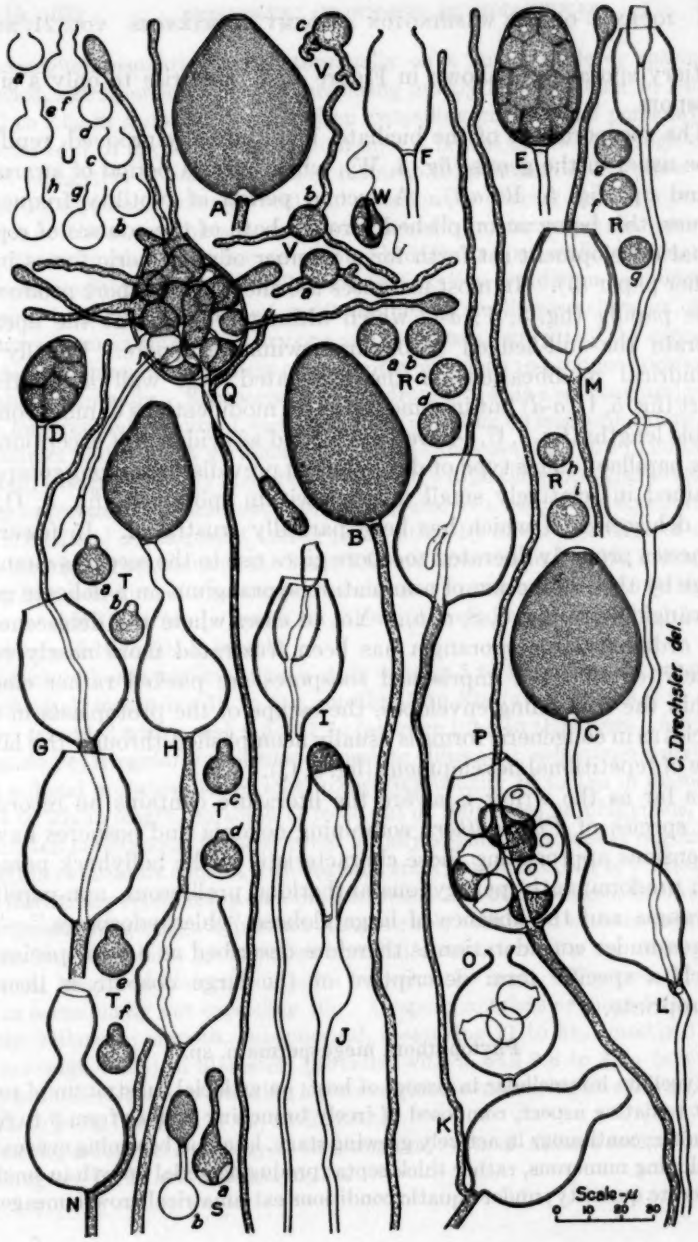

Fig. 5. *Phytophthora megasperma.* For explanation see page 522.

tertiary sporangium shown in Figure 5, I, give rise to only a single zoospore.

The zoospores are of the biciliate, longitudinally grooved, reniform type usual in the genus (fig. 5, W), which after a period of swarming round up (fig. 5, R, *a-i*). A second period of motility frequently ensues, this being accomplished through both of the courses of repetitional development set forth for a number of congeneric forms in an earlier paper (5). In most instances the encysted zoospore produces a wide papilla (fig. 5, T, *a-f*) which ultimately yields at the apex to liberate the full-fledged secondary swimming spore. Usually the cylindrical modification on the evacuated cyst wall is relatively short (fig. 5, U, *a-d*) but in some instances modifications of more considerable lengths (fig. 5, U, e-h) remain behind as evidence of exceptionally long papillae. This type of development prevails also among zoospores retained in relatively small number within sporangia (fig. 5, O, P) the dehiscence of which has been partially frustrated. In fewer instances a properly liberated zoospore gives rise to the second swimming stage by the production of a miniature sporangium on a delicate germ sporangiophore (fig. 5, S, *a*, *b*). Yet in cases where the dehiscence of the ordinary large sporangia has been frustrated more nearly completely, so that the imprisoned zoospores are packed rather closely within the containing envelopes, the escape of the protoplasts in this species as in congeneric forms is usually acomplished through the latter type of repetitional development (fig. 5, Q).

As far as the writer is aware the literature contains no record of any species of *Phytophthora* combining oogonia and oospores having dimensions approaching those characteristic of the hollyhock parasite with predominantly paragynous antheridia, proliferous, non-papillate sporangia and the absence of large globose "chlamydospores." The fungus under consideration is therefore described as a new species for which a specific term descriptive of the large oospore is deemed appropriate.

Phytophthora megasperma n. sp.

Mycelium intercellular in tissues of host; on artificial substratum of somewhat radiating aspect, composed of freely branching hyphae from 3 to 8μ in diameter; continuous in actively growing stage, later, on becoming evacuated, developing numerous, rather thick septa; producing aerial growth in small or moderate quantity; under aquatic conditions extramatrical growth meager.

Sporangium regularly formed terminally on a long, simple or sparingly branched, extramatrical filament measuring mostly 50μ to 2 mm. in length and 2 to 2.5μ in diameter, though often expanding in the distal portion to a diameter of 3 to 5μ; later often coming into a lateral position through continued elongation of the supporting filament from immediately below the delimiting septum; regularly ovoid, but occasionally bearing distally a protuberance or lobe of variable size; measuring 6 to 45μ in transverse diameter by 15 to 60μ in length; on dehiscence opening broadly at apex without formation of an outwardly protruding papilla; after evacuation proliferous in moderate measure, both by formation of sessile or nearly sessile secondary or often tertiary sporangia within primary one and by repeated growth of the supporting filament through the orifices of the empty envelope to produce additional sporangia externally. Zoospores produced from 1 to 45 in a sporangium; reniform, longitudinally grooved, biciliated, after rounding up measuring 10 to 13μ in diameter; individually germinating by germ-tubes usually 1 to 3 in number, or often, whether properly liberated or retained within the sporangial envelope owing to frustrated dehiscence, often giving rise to a secondary zoospore,—the repetitional development taking place either by direct discharge of contents through an evacuation tube 3.5 to 5.5μ in diameter and 1 to 10μ in length, or by the production of an elongated miniature sporangium mostly 6 to 10μ in diameter and 16 to 22μ in length on a germ sporangiophore mostly 1.5μ in diameter and 10 to 60μ in length.

Oogonium borne terminally on a stalk usually 5 to 15μ in length; smooth, subspherical, measuring 16 to 61μ, mostly 42 to 52μ (average 47.4μ) in diameter; provided with a wall 0.5 to 1.7μ (average 1.2μ) in thickness. Antheridium single; irregularly orbicular or prolate ellipsoidal, sometimes provided with a distal protuberance or lobe; measuring usually 10 to 18μ in diameter by 14 to 20μ in length; in some (1 to 35 out of 100) cases amphigynous, but more often paragynous, in latter event usually applied near base of oogonium and often in intimate contact with oogonial stalk; borne laterally or terminally or in intercalary relationship on a branch mostly 5 to 50μ in length, the branch sometimes arising from a hypha not demonstrably connected with the oogonial hypha, but sometimes having close mycelial connection with the oogonium, the total length of filamentous parts between the septa delimiting the sex organs occasionally not exceeding 40μ. Oospore colorless or more often distinctly yellowish; smooth, subspherical, measuring 11 to 54μ, mostly 37 to 47μ (average 41.4μ) in diameter; provided with a wall 0.8 to 4.6μ (average 3.6μ) in thickness, and containing a reserve globule measuring at early maturity 6.5 to 24.0μ (average 17.6μ) in diameter.

Causing a destructive decay of the stem and roots of *Althaea rosea* Cav. in Washington, D. C. and at Rosslyn, Va.

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BOTANY.—*The Genus* Chikusichloa *of Japan and China.*[1] Y. L. KENG,[2] U. S. National Herbarium. (Communicated by A. S. HITCHCOCK.)

In 1925 *Chikusichloa* was described with a single species and was regarded as an endemic genus in Japan. This grass, however, was recently found in China and a second species as well. The new species is from the Kwangsi collection of Mr. R. C. Ching in 1928, the other from my Kiangsu (I-shing) collection in 1929.

CHIKUSICHLOA Koidz. Bot. Mag. Tokyo **39**: 23. 1925. A single species, *C. aquatica* Koidz., is described from Japan.

Spikelets perfect, 1-flowered, somewhat laterally compressed or subterete, the disarticulation a short distance below the lemma, the spikelets falling with a stipe attached; glumes wanting; lemma lanceolate, attenuate into a terminal awn or acuminate, membranaceous, strongly 5-7-nerved; palea a little shorter and thinner than the lemma, 2-3-nerved; styles distinct, the stigmas laterally exserted; stamen 1, the anther linear; lodicules 2, minute; grain hard, fusiform, the pericarp adnate to the mealy seed. Aquatic peren-

[1] Received November 13, 1931.

[2] Fellowship student of the Rockefeller Foundation, from the National Central University, Nanking, China.

nials with simple culms, narrow blades, and terminal panicles.—Species 2, one in Japan and Southeastern China, the other in Southwestern China.

A. Spikelets awned, the stipe 2-4 mm. long, usually longer than the branchlet below the joint.....1. *C. aquatica.*

AA. Spikelets awnless, the stipe 1-2 mm. long, equaling or shorter than the branchlet below the joint.....2. *C. mutica.*

This genus belongs to the tribe Oryzeae, but approaches the American genus *Zizaniopsis*, which is differentiated from Oryzeae by the unisexual spikelets. Though the spikelets in *Chikusichloa* are all alike, those in the upper part of the panicle are usually more fruitful than those in the lower. Moreover, there seems to be a tendency toward reduction in the size of the anthers in the spikelets of the lower part of the panicle, suggesting a trend toward two kinds of spikelets, one pistillate, the other perfect. The perfect stipitate spikelets recall those of *Hygroryza*, but in that the stamens are 6, and the plant is floating, with inflated sheaths, short broad blades, and small panicles. In the original description of *Chikusichloa* the stipe remaining attached to the lemma is considered to be the elongated lower joint of the rachilla. Since here, as well as in *Hygroryza*, the glumes are wanting, it is not certain whether the stipe is an elongated rachilla-joint or the summit of a pedicel which disarticulates some distance below the spikelet. Such pedicels are characteristic of *Thysanolaena* and *Polypogon*, and are found in some species of *Trisetum*, where the presence of glumes at the apex of the stipe shows conclusively that the stipe is part of the pedicel.

CHIKUSICHLOA AQUATICA Koidz. Bot. Mag. Tokyo **39:** 23. 1925

Culms tufted, erect, 0.8–1.5 meters tall, subcompressed, 3–5 mm. thick, 5-noded, the lower nodes remote, the upper ones approximate; sheaths loose, compressed-keeled, much longer than the internodes; blades 45–60 cm. long, 8–14 mm. wide, acuminate, flat or folded, deep green, rather flaccid; panicle lanceolate, erect, half to one third the length of the plant, the branches slender, ascending, up to one third the length of the panicle; spikelets dull green, 3–5 mm. long, terminating in a slender awn 3–6 mm. long, hispidulous along the nerves; stipe 2–4 mm. long, or rarely shorter, hispidulous; anther 1–1.5 mm. long; grain 2–2.5 mm. long, dark or brownish.—Shady sides of mountain streams, Japan and Southeastern China.

CHINA: Kiangsu, I-shing, *Keng* 2496.

One Japanese specimen, collected from Satsuma by Masamune in 1925, has been examined. It differs in having a stipe as much as 6 mm. long, but is similar otherwise to that of China.

Chikusichloa mutica Keng, sp. nov.

Culmi caespitosi, erect, circ. 75 cm. alti, 3 mm. crassi, subcompressi, glabri; vaginae laxae, compresso-carinatae, internodiis longiores; ligula firma, glabra, 3–5 mm. longa; laminae erectae, saepe conduplicatae et falcatae, 15–40 cm.

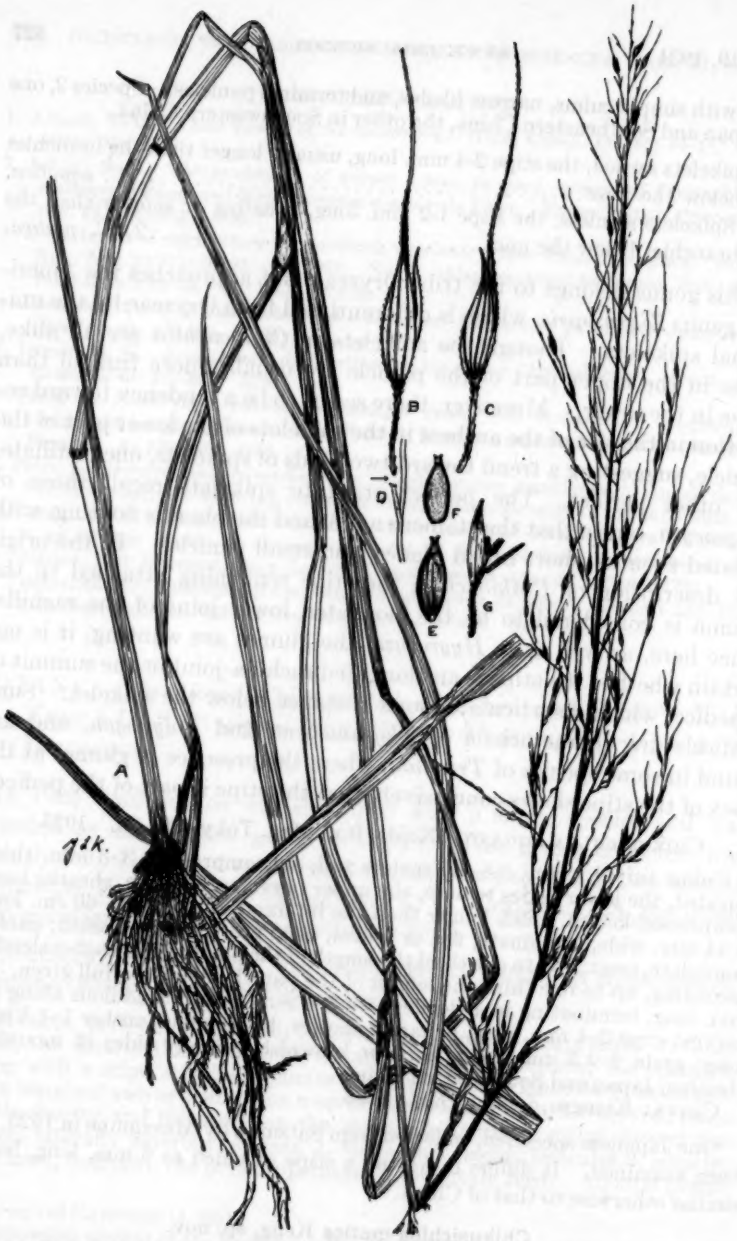

Fig. 1. *Chikusichloa aquatica* Koitz. For explanation see page 529.

longae, expansae 10–16 mm. latae, acuminatae, firmae, glaucae, costa media superne obscura, inferne prominente; panicula contracta, linearis, 20–30 cm. longa, ramis tenuibus, alternis, erectis vel appressis, usque 7 cm. longis; spiculae anguste lanceolatae, 4 mm. longae, acuminatae, muticae, lacteae, inter nervos validos hispidulos glabrae et interdum plicatae; stipes 1–2 mm. longus, hispidulus; stamen unum, anthera usque 2 mm. longa; styli distincti, stigmatibus multo breviores.

Culms tufted, erect, about 75 cm. tall, 3 mm. thick, subcompressed, glabrous; sheaths loose, compressed-keeled, the upper ones crowded on the approximate nodes; ligule firm, glabrous, 3–5 mm. long; blades erect, usually folded and falcate, 15–40 cm. long, 10–16 mm. wide, acuminate, firm, glaucous, the midrib obscure above, prominent beneath; panicle contracted, linear, 20–30 cm. long, the branches slender, appressed, up to 7 cm. long; spikelets narrowly lanceolate, 4 mm. long, acuminate, awnless, rarely mucronulate, creamy-white, glabrous and sometimes folded between the hispidulous strong nerves; stipe 1–2 mm. long, hispidulous, equaling or more frequently shorter than the glabrous branchlet below the joint; stamen 1, the anther up to 2 mm. long; styles distinct, much shorter than the stigmas.

Type in the Herbarium of the Metropolitan Museum of Natural History, Academia Sinica, Nanking, China, collected by the side of a stream in ravine, Seh Fing Dar Shan, Nanning, Kwangsi, altitude 600 meters, October 24, 1928, by *R. C. Ching* (no. 8200). Duplicate type in the U. S. National Herbarium (no. 1501590).

Fig. 2. *Chikusichloa mutica* Keng. A. Part of a panicle branch, ×2. B. Stamen, pistil, and lodicules, drawn from a spikelet on the upper part of the panicle, ×10. C. Same from a spikelet near the base of the panicle, ×10. D. Spikelet and its stipe, ×5. E-F. Lemma and palea, ×5.

Fig. 1. *Chikusichloa aquatica* Koidz. A. Plant, ½ natural size. B-C. Fruitful spikelets and stipes, ×5. D. The articulation showing the branchlet persistent below the joint, ×5. E-F. Caryopsis and its section showing the pericarp adnate to the mealy seed, ×5. G. Young spikelet on the lower part of the panicle, with its lemma removed, ×10.

This species is closely related to *Chikusichloa aquatica*, from which it differs chiefly in the awnless cream-white spikelets, shorter stipes, linear panicles, and in the glaucous firm blades. The specimens seen consist of the upper part of the plant, about 60 cm. long, with 4 leaves crowded above and the lower internodes 7–11 cm. long.

MAMMALOGY.—*Six new white-footed mice* (Peromyscus maniculatus *group), from islands off the Pacific Coast.*[1] E. W. NELSON and E. A. GOLDMAN, U. S. Biological Survey.

In *Revision of the mice of the American genus Peromyscus* (North Amer. Fauna, No. 28, pp. 96–98, Apr. 17, 1909) Osgood referred specimens from the islands of San Miguel, San Nicolas, Santa Barbara, and Santa Rosa of the Santa Barbara group, off the coast of southern California, to *Peromyscus maniculatus clementis* which was originally described from San Clemente Island. Those from Santa Cruz Island were assigned to *P. m. catalinae*, of Santa Catalina Island. Specimens from Natividad Island and San Martin Island, off the coast of Lower California, were referred (l. c., p. 100) to *P. m. geronimensis*, typical on San Geronimo Island.

More than 20 years have passed since the fine monograph mentioned was published. In commenting upon material examined from the various islands the author pointed out in several instances characters which he regarded as too slight to afford a basis for satisfactory separation. Finer distinctions are being made by many workers at the present time, and it seems to us probable that if the same reviser were reviewing this part of his work his viewpoint would be somewhat altered. Some of the islands are separated by 50 miles or more of open sea, while others lie somewhat nearer together. San Miguel and Santa Rosa Islands, with a comparatively narrow passage between them, appear to be inhabited by the same form. Study of the fairly ample material available has shown that although the characters presented in varying combinations from island to island are relatively slight they are maintained with rather remarkable constancy. Such characters are, as in many other similar places, the expression of genetic factors resulting through isolation and response to environmental influences favoring their perpetuation. These insular forms, with ranges sharply

[1] Received November 19, 1931.

definable, are more readily and satisfactorily segregated than would be the case with many similarly differentiated mainland forms with ranges merging almost imperceptibly. We believe they should be recognized as interesting and tangible steps in the evolutionary process involved in the development of species.

New subspecies are described as follows:

Peromyscus maniculatus streatori subsp. nov.

San Miguel Island Mouse

Type.—From San Miguel Island, off coast of southern California. No. 34631/46716, ♂ old adult, U. S. National Museum (Biological Survey collection), collected by C. P. Streator, June 24, 1892. Original number 1861.

Distribution.—San Miguel and Santa Rosa Islands.

General characters.—A dark subspecies, similar to *Peromyscus maniculatus clementis* of San Clemente Island, but darker and browner, less buffy; general size about the same but ears usually slightly smaller; skull more slender in structure. Closely resembling *P. m. catalinae* in color; general size similar, but tail longer; ears slightly smaller; cranial characters, especially the smaller braincase, distinctive.

Color.—*Type*: Upper parts in general near wood brown (Ridgway, 1912) with a dull cinnamon suffusion on cheeks, shoulders, and along sides, the top of head and back moderately mixed with black; underparts in general dull white; a small ochraceous buffy area at base of tail; forelimbs and hind feet white; ears dusky, indistinctly edged with white; tail bicolor, brownish above, white below.

Skull.—Similar to that of *P. m. clementis* but of slenderer proportions, the rostrum narrower, more attenuate; interorbital region narrower; interparietal smaller (shorter antero-posteriorly). Compared with that of *P. m. catalinae* the skull differs notably as follows: Braincase smaller, less inflated; interorbital region narrower; interparietal smaller (shorter antero-posteriorly).

Measurements.—*Type*: Total length, 170 mm.; tail vertebrae, 80; hind foot, 20. Average of 10 adult topotypes: 175 (160–185); 82 (77–86); 21 (21–22). *Skull* (type): Greatest length, 25.7; condylobasal length, 23.5; zygomatic breadth, 13.2; interorbital breadth, 4; interparietal, 9.1 × 2.1; length of nasals, 10.5; maxillary toothrow, 3.7.

Remarks.—*P. m. streatori* is one of the smaller forms of *P. maniculatus* inhabiting the Santa Barbara group of islands. It is larger and darker-colored and scarcely requires close comparison with *P. m. gambeli*, of the adjacent mainland. Specimens from Santa Rosa Island appear to be inseparable from those from San Miguel Island.

Specimens examined.—Total number, 38, as follows:

California: San Miguel Island (type locality), 25; Santa Rosa Island, 13.

Peromyscus maniculatus santacruzae subsp. nov.

Santa Cruz Island Mouse

Type.—From Santa Cruz Island, off coast of southern California. No. 47449, ♀ old adult, U. S. National Museum (Biological Survey collection), collected by C. P. Streator, July 13, 1892. Original number 1923.

Distribution.—Known only from Santa Cruz Island.

General characters.—A large dark subspecies, closely allied to its geographic neighbor *Peromyscus maniculatus streatori*, of San Miguel Island, but usually decidedly larger with very noticeably longer tail; color about the same. Similar to *P. m. catalinae*, of Santa Catalina Island, but tail longer, ears usually smaller, and cranial details distinctive. Differing from *P. m. clementis* as follows: General size larger, tail decidedly longer; color somewhat duller, more brownish, less suffused with buff; buffy lateral line less distinct.

Color.—Type: Upper parts near wood brown, suffused with cinnamon buff on cheeks, shoulders, flanks, and outer surfaces of limbs, the top of head and back moderately overlaid with brownish black; under parts dull white; ears dusky, indistinctly edged with white; tail bicolor, brownish above, whitish below.

Skull.—Closely resembling that of *P. m. streatori*, but larger and heavier; interparietal small as in *streatori*. Similar to that of *P. m. catalinae*, but braincase somewhat smaller, less fully inflated; interorbital region usually narrower; interparietal smaller (shorter antero-posteriorly). Compared with that of *P. m. clementis* the skull is similar in general form, but larger; interparietal smaller (shorter antero-posteriorly).

Measurements.—Type: Total length, 207; tail vertebrae, 99; hind foot, 22. Average of 10 adult topotypes: 194 (184-214); 96 (88–105); 22 (21–23). *Skull* (type): Greatest length, 27.7; condylobasal length, 25.7; zygomatic breadth, 14.4; interorbital breadth, 4.2; interparietal, 8.7 x 2.6; length of nasals, 11.2; maxillary toothrow, 3.9.

Remarks.—P. m. santacruzae is a large subspecies interposed in geographic range between the smaller form, *P. m. streatori* of San Miguel and Santa Rosa Islands and the still smaller mainland animal, *P. m. gambeli*. It differs conspicuously from the latter not only in larger size, but in darker color. The smaller ears of specimens from Santa Cruz Island, compared with typical *P. m. catalinae* was pointed out by Osgood (l. c. p. 98).

Specimens examined.—Twenty-five, all from Santa Cruz Island.

Peromyscus maniculatus exterus subsp. nov.

San Nicolas Island Mouse

Type.—From San Nicolas Island, off coast of southern California. No. 92098, ♀ old adult, U. S. National Museum (Biological Survey collection), collected by H. A. Gaylord, May 23, 1897.

Distribution.—Known only from San Nicolas Island.

General characters.—One of the smaller of the California insular races, very similar to *Peromyscus maniculatus streatori* of San Miguel Island, but ears larger; color paler, more cinnamon buffy, less brownish or dusky, especially on posterior part of dorsum. Similar to *P. m. clementis*, but lighter buff, and cranial details quite distinctive. Decidedly smaller in general than *P. m. santacruzae*, but with slightly larger ears; color brighter, more buffy, less brownish, the lateral line more distinct. Differing from *P. m. catalinae* in lighter, more buffy instead of brownish color, the lateral line more evident; skull exhibiting a departure in detail.

Color.—Type: Upper parts cinnamon buff, purest on cheeks, shoulders, lateral line and interfemoral area, the top of head and back moderately overlaid with brownish black; under parts white; ears dusky, faintly edged with white; outer sides of forearms cinnamon buffy; outer sides of ankles dark brownish; tail bicolor, brownish above, white below.

Skull.—Closely similar to that of *P. m. streatori*, but upper outline highest near anterior border of frontals (highest near posterior border in *streatori*); braincase slightly larger; interparietal short (antero-posteriorly) as in *streatori*. Compared with that of *P. m. clementis* the skull is slenderer, with narrower and slightly flatter frontal region; nasals narrower; outer wall of antorbital foramen narrower, as viewed from the side; interparietal smaller (shorter antero-posteriorly). In contrast with *P. m. catalinae* the braincase is smaller, less fully inflated; interorbital region narrower; interparietal smaller (shorter antero-posteriorly). Differing from that of *P. m. santacruzae* mainly in smaller size.

Measurements.—Type: Total length, 183; tail vertebrae, 88; hind foot (dry skin), 20. Average of 10 adult topotypes: 177 (171–187); 82 (76–88); 20 (19.5–21). *Skull* (type): Greatest length, 25.7; condylobasal length, 23.5; zygomatic breadth, 23; interorbital breadth, 4; interparietal, 8.2 x 1.9; length of nasals, 10.3; maxillary toothrow, 3.8.

Remarks.—P. m. exterus inhabits the outermost of the Santa Barbara group of islands. Cranial characters indicate closer relationship to *P. m. streatori* of the islands of San Miguel and Santa Rosa to the northwest than to *P. m. clementis* of San Clemente Island, nearly equidistant to the southeast. In paler, more buffy coloration, however, it tends toward *clementis* which in turn is paler as compared with *P. m. catalinae*. The somewhat lighter coloration of the mice on these farther off shore islands suggests the presence of some differential influence. Many animals from within the fog belt along the Pacific coast are well known to exhibit dark colors. Possibly fog is less prevalent on San Nicolas and San Clemente, which are 50 miles or more off shore, than on the other islands all of which are considerably nearer the coast.

Specimens examined.—Twenty-four, all from San Nicolas Island.

Peromyscus maniculatus elusus subsp. nov.

Santa Barbara Island Mouse

Type.—From Santa Barbara Island, off coast of southern California. No. 92049, ♂ adult, U. S. National Museum (Biological Survey collection), collected by H. A. Gaylord, May 16, 1897. X catalogue number 1095.

Distribution.—Known only from Santa Barbara Island.

General characters.—A dull brownish subspecies similar to *Peromyscus maniculatus clementis* but upper parts darker, the general tone brownish instead of buffy; skull differing in detail. Approaching *P. m. catalinae* in color, but ears smaller, and cranial characters distinctive. Closely resembling *P. m. santacruzae*; color about the same; size smaller; tail decidedly shorter; skull slightly different. Similar to *P. m. exterus* of San Nicolas Island, but darker, duller, more brownish in color; ears slightly smaller; skull diverging in minor features.

Color.—Type: Upper parts in general near wood brown, moderately mixed with black on top of head and over back; lateral line pinkish buff, but rather indistinct; under parts dull white; ears dusky, faintly edged with white; outer sides of forearms and hind legs buffy brownish; tail bicolor, brownish black above, white below.

Skull.—Very similar to that of *P. m. clementis*, but interparietal smaller (shorter antero-posteriorly); frontal region slightly flatter, with a less distinct longitudinal median groove or trough. Compared with *P. m. catalinae* the braincase is smaller, flatter, less inflated, and the interparietal is smaller. Slightly broader and heavier than *P. m. streatori* or *P. m. exterus*; rostrum and interorbital region broader; parietal with antero-external angle forming a less acute point. Differing from *P. m santacruzae* mainly in smaller size and slightly rounded, instead of acutely pointed, antero-external angle of parietal.

Measurements.—Type: Total length, 166; tail vertebrate, 70; hind foot (dry skin), 20. Average of six adult topotypes: 174 (165–190); 75 (67–88); 20 (20–21). *Skull* (type): Greatest length, 26; condylobasal length, 23.3; zygomatic breadth, 12.6; interorbital breadth, 4.3; interparietal, 9.3 x 2; length of nasals, 10.3; maxillary toothrow, 3.8.

Remarks.—Specimens from Santa Barbara Island have hitherto been referred to *P. m. clementis* which was originally described from San Clemente Island. A difference in color, however, while not striking is quite appreciable, especially when the series from the two islands are placed side by side; and the slight cranial characters are distinctive. In color *P. m. elusus* more nearly resembles *P. m. santacruzae*, and the skulls are not widely different, but it averages decidedly smaller, and the slightly rounded, instead of acutely pointed, antero-external angle of the parietal is quite constant.

Specimens examined.—Twenty, all from Santa Barbara Island.

Peromyscus maniculatus martinensis subsp. nov.

San Martin Island Mouse

Type.—From San Martin Island, off west coast of Lower California, Mexico. No. 138979, ♀ adult, U. S. National Museum (Biological Survey collection), collected by Nelson and Goldman, August 13, 1905. Original number 17726.

Distribution.—Known only from San Martin Island.

General characters.—A large medium-colored (neither very light nor very dark) insular subspecies, distinguished from its near relatives by a combination of slight but fairly constant cranial details. Very similar to *Peromyscus maniculatus geronimensis* of San Geronimo Island; size and color about the same, but differing especially in the broader, less tapering rostrum and more projecting supraoccipital region. Decidedly paler than *P. m. dubius*, of Todos Santos Island, and skull differing in minor features. Paler than *P. m. gambeli* and darker than *P. m. coolidgei*, and larger, more robust, than either of these mainland forms.

Color.—Type: Upper parts cinnamon buff, purest on cheeks, shoulders, and distinct lateral line, moderately mixed with black on top of head and over back; under parts in general dull white, the basal color plumbeous except on throat and lips where the short hairs are white to roots; a small buffy area at base of tail; fore limbs whitish; outer sides of hind legs dull buffy, becoming whitish on feet; ears brownish dusky, narrowly and inconspicuously edged with white; tail brownish above, white below. Some of the topotypes are lighter and others darker above than the type.

Skull.—Very similar in size and general form to that of *P. m. geronimensis*, but frontal region slightly more arched, less flattened anteriorly; rostrum usually broader, nasals broader, less tapering anteriorly; supraoccipital with a more prominent posteriorly projecting median angle, this portion of the cranium extending farther over the foramen magnum beyond the plane of

the condyles; palatal pits larger. Not very unlike that of *P. m. dubius*, but interparietal smaller; nasals usually narrower.

Measurements.—Type: Total length, 184; tail vertebrae, 82; hind foot, 23. Average of three adult topotypes: 182 (178–185); 81 (75–87); 22.5 (22–23). *Skull* (type): Greatest length, 27; condylobasal length, 26.3; zygomatic breadth, 12.8; interorbital breadth, 4.2; interparietal, 9.8 x 2.3; length of nasals, 10.3; maxillary toothrow, 4.

Remarks.—In size and external appearance *P. m. martinensis* closely approaches *P. m. geronimensis* to which the specimens upon which it is based were referred by Osgood (l. c., p. 100). The greater average width of the nasals, as compared with typical *geronimensis* was pointed out by him, and this together with the other differential cranial features mentioned here are regarded by us as sufficiently distinctive to warrant a separate name.

Specimens examined.—Fifty, all from San Martin Island.

Peromyscus maniculatus dorsalis subsp. nov.

Natividad Island Mouse

Type.—From Natividad Island, off west coast of Lower California, Mexico. No. 80857, ♀ adult, U. S. National Museum (Biological Survey collection), collected by A. W. Anthony, August 4, 1896. Original number 96.

Distribution.—Known only from Natividad Island.

General characters.—A large subspecies similar to *Peromyscus maniculatus geronimensis*, of San Geronimo Island, but less buffy, the face usually paler and the posterior part of back and rump in contrast more heavily overlaid with black; minor cranial features distinctive. Differing from *P. m. cineritius*, of San Roque Island, in darker color.

Color.—Type: Head and anterior part of back grayish or light buffy brownish in contrast with posterior part of back and rump which is pinkish buff heavily overlaid with black; flanks buffy brownish; under parts dull white; fore limbs whitish; outer sides of hind legs buffy brownish becoming white on feet; ears dusky externally, thinly clothed internally and narrowly edged with white; tail bicolor, brownish above, white below.

Skull.—Size and general form about as in *P. m. geronimensis*, but nasals usually broader, less tapering anteriorly; outer wall of antorbital foramen broader, the anterior margin more rounded and projecting (more squarely truncate in *geronimensis*) as viewed from the side. Compared with that of *P. m. coolidgei* of the adjacent mainland the skull is larger, more robust, and differs in detail about as from *geronimensis*.

Measurements.—Type: Total length, 177; tail vertebrae, 73; hind foot (dry skin), 22.5. Average of three adult topotypes: 176 (174–183); 79 (75–83); 23 (22.5–23.5). *Skull* (type): Greatest length, 26.1; condylobasal length, 3.3; zygomatic breadth, 23.5; interorbital breadth, 24.2; interparietal, 9.3 x 2.8; length of nasals, 9.8; maxillary toothrow, 4.

Remarks.—P. m. dorsalis lacks the richer cinnamon buffy tones of *P. m. geronimensis*. The head and anterior part of the back are paler and grayer while the posterior part of the back and rump, suffused with lighter buff, becomes rather abruptly more heavily overlaid with black. No specimens of *P. m. cineritius*, of San Roque Island, are at hand for direct comparison, but that animal is described as pale grayish drab and apparently quite unlike the present form. *P. m. dorsalis* requires no close comparison with the smaller, paler subspecies, *P. m. coolidgei*, of the adjacent mainland.

Specimens examined.—Twenty-one, all from Natividad Island.

ZOOLOGY.—Neotylenchus abulbosus *n. g., n. sp.* (*Tylenchidae, Nematoda*) *the causal agent of a new nematosis of various crop plants.*[1] G. STEINER, Bureau of Plant Industry.

During the last two years the nemic plant parasite, *Neotylenchus abulbosus* n. g., n. sp., has been observed in strawberry plants affected by so-called "yellows" or "xanthosis," received from Mr. Harold E. Thomas of California; in strawberry plants from Wisconsin and from Germany; in potatoes in ships' stores from England, Holland, Norway, and New Brunswick, Canada; and in carrots from England and Sweden. The form at first sight resembles *Tylenchus dipsaci*, and it is probable that it has sometimes been mistaken for it. The present paper gives the result of a single experiment, and a summary of observations, and morphological and taxonomic data concerning the new genus and species.

In strawberry plants this nema occurs in the bud,—between the folded leaves and stems,—and also in the developed stems and leaves, and is undoubtedly an endoparasite. In the above mentioned California plants, the nemas were extremely numerous in brownish, blackish or yellowish spots of the leaves. We have not yet been able experimentally to produce such spots, but the single negative experiment is not conclusive.

The Wisconsin strawberry plants, were somewhat dwarfed and looked abnormal, without exhibiting very special symptoms; they contained this nema only in small numbers. A lot of strawberry plants imported from Germany seemed to be 100% infested; they had, however been packed close together in transit. The few old leaves present exhibited brown spots or decayed parts. Young tender leaves had developed, though they were not completely unfolded. Nemas were found in their tissues, and in the bud between developing leaves. Some of the leaf stems seemed to be slightly swollen, apparently because of the infestation. It is therefore impossible at the present time to describe satisfactorily clear-cut symptoms of this nemic disease on the strawberry plant.

The carrots seen exhibited sunken areas, which, however, were filled with decay; no green parts have been available for study. The potato tubers also were too decayed when received to allow specific symptoms to be recognized, though the appearances seem much like those pro-

[1] Received November 20, 1931.

duced by *Tylenchus dipsaci*. Certain areas were sunken and the tuber tissues exhibited a mealy appearance.

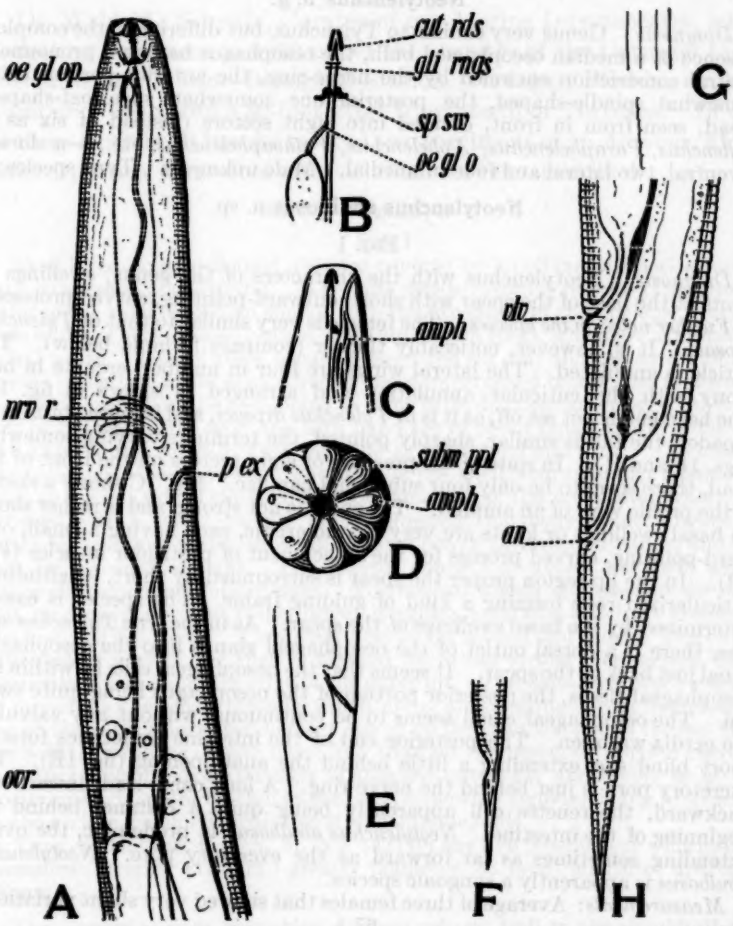

Fig. 1. *A*. Sketch of the anterior end; *B*, of the spear; *C*, amphid; *D*, head on end; *E*, anal region of a specimen with caecal extension of the intestine; *F*, tail end; *G*, lateral wings showing nature of crenation; *H*, posterior end. All ×530 except "D" which is ×1075. The abbreviations are mostly self explanatory; *oe gl op*, opening of dorsal oesophageal gland; *cut rds*, cuticular rods of the framework in the lip region; *gli rngs*, gliding rings of the spear; *sp sw*, swellings at base of the spear.

It is considered probable that this nema has a wide geographical distribution; but it appears at present to be a temperate zone species.

Neotylenchus n. g.

Diagnosis. Genus very similar to Tylenchus, but differing in the complete absence of a median oesophageal bulb, the oesophagus having a pronounced central constriction encircled by the nerve-ring, the anterior portion being somewhat spindle-shaped, the posterior one somewhat sugarloaf-shaped. Head, seen from in front, divided into eight sectors (instead of six as in *Tylenchus, Paraphelenchus, Aphelenchus, Pathoaphelenchus,* etc.,)—a dorsal, a ventral, two lateral and four submedial. Male unknown. Type species:

Neotylenchus abulbosus n. sp.

FIG. 1

Diagnosis. Neotylenchus with the characters of the genus; swellings or knots at the base of the spear with short, outward-pointing, curved processes.

Further notes on the species. The female is very similar to that of *Tylenchus dipsaci.* It is, however, noticeably thicker (compare formula below). The cuticle is annulated. The lateral wings are four in number, crenate in harmony with the cuticular annulation and arranged as shown in fig. 1G. The head end is not set off, as it is in *Tylenchus dipsaci,* and is more obtuse and broader; the tail is similar, sharply pointed, the terminus varying somewhat (figs. 1F and H). In spite of the presence of eight sectors on the front of the head, there seem to be only four submedial papillae. Fig. 1C shows a sketch of the profile view of an amphid. The spear is not strong, and is rather short; its basal swellings or knots are very characteristic, each having a small, outward-pointing, curved process for the attachment of protrudor muscles (Fig. 1B). In the lip region proper the spear is surrounded by short, longitudinal, cuticularized rods forming a kind of guiding frame. The species is easiest determined by the basal swellings of the spear. As in the true *Tylenchus* species, there is a dorsal outlet of the oesophageal glands into the oesophageal canal just back of the spear. It seems that the oesophageal cells lie within the oesophageal tissus, the posterior portion of the oesophagus being quite swollen. The oesophageal canal seems to be continuous, without any valvulae. No cardia was seen. The posterior end of the intestine sometimes forms a short blind sac, extending a little behind the anal opening (fig. 1E). The excretory pore is just behind the nerve-ring. A long canal leads inward and backward, the renette cell apparently being quite a distance behind the beginning of the intestine. *Neotylenchus abulbosus* is prodelphic, the ovary extending sometimes as far forward as the excretory pore. *Neotylenchus abulbosus* is apparently a syngonic species.

Measurements: Average of three females that showed very slight variations.

			67.		
1.4	9.3	18.	−85.	90.5	0.76 mm.
2.0	3.7	4.1	3.7	3.0	

MALACOLOGY.—*A new volutid marine mollusk,* Aurinia schmitti.[1]

PAUL BARTSCH, U. S. National Museum.

Dr. Waldo L. Schmitt, Curator of our Marine Invertebrates, while collecting Crustacea in 1930 under the auspices of the Carnegie Institution at the Marine Biological Station, Tortugas, Florida, made a number of hauls with a 30-foot otter trawl south of Tortugas. In one of these hauls in 80 fms. he secured two specimens of an *Aurinia*, which differ from any heretofore secured; these are here described.

Aurinia schmitti, n. sp.

Fig. 1.

Shell large, spindle-shaped, exterior covered by an olivaceous periostracum which dehisced upon drying. When the periostracum is removed the general color of the shell is pinkish chalky with the exception of the nucleus, which is pale buff. There are also rows of chestnut-brown spots, which are arranged in spiral series. Two of these occur between the summit and the suture of the turns. The last whorl shows five of these interrupted bands; the first much less developed than the rest, being at some little distance anterior to the summit of the whorl; the next and fifth band are of about equal width, while the third and fourth are fully twice as wide as the second and fifth. The base of the columella is also brown. The front of the shell from the inner columellar edge to the left side of the shell and the same area of the proceeding whorl, are covered with a soiled, smoky gray, somewhat nacreous callus. Inside of outer lip salmon-colored, showing the two heavy interrupted bands, and the rest by transmitted light. The nucleus consists of about one turn, which forms a smooth mammilated apex. Postnuclear whorls appressed at the summit, marked by obsolete, rather broad, irregular, axial ribs, which are absent on the first and last turns. They show best on the second and third. The entire postnuclear part of the shell is marked by rather strong incremental lines, particularly so behind the edge of the outer lip. The spiral sculpture consists of numerous fine raised threads, which are of almost equal strength and spacing on the early whorls, but become less so on the later whorls; on the last they are a little stronger on the basal half than on the posterior portion thereof. Aperture elongate-oval, strongly channelled anteriorly and feebly so at the posterior angle; outer lip thin at the edge, somewhat sigmoid, being protracted in the middle, columella with two strong oblique folds.

Type.—The type, U.S. N. M. No. 382779, has five postnuclear whorls, and measures: Height, 115 mm.; greater diameter, 35 mm.; length of aperture, 78 mm.

The present species resembles *Aurinia robusta* Dall in the shouldering of the last turn at the posterior angle of the aperture, which is even more strongly emphasized here. The spotting, too, is obscure as in that species. It also resembles it in the callus formation of the front of the last turn. In general shape, excepting the posterior angle of the aperture, it resembles *Aurinia*

[1] Published by permission of the Secretary of the Smithsonian Institution. Received November 10, 1931.

dubia Broderip more closely than *Aurinia robusta* Dall, but it is at once distinguished from it by the absence of the polished surface and brilliant spotting.

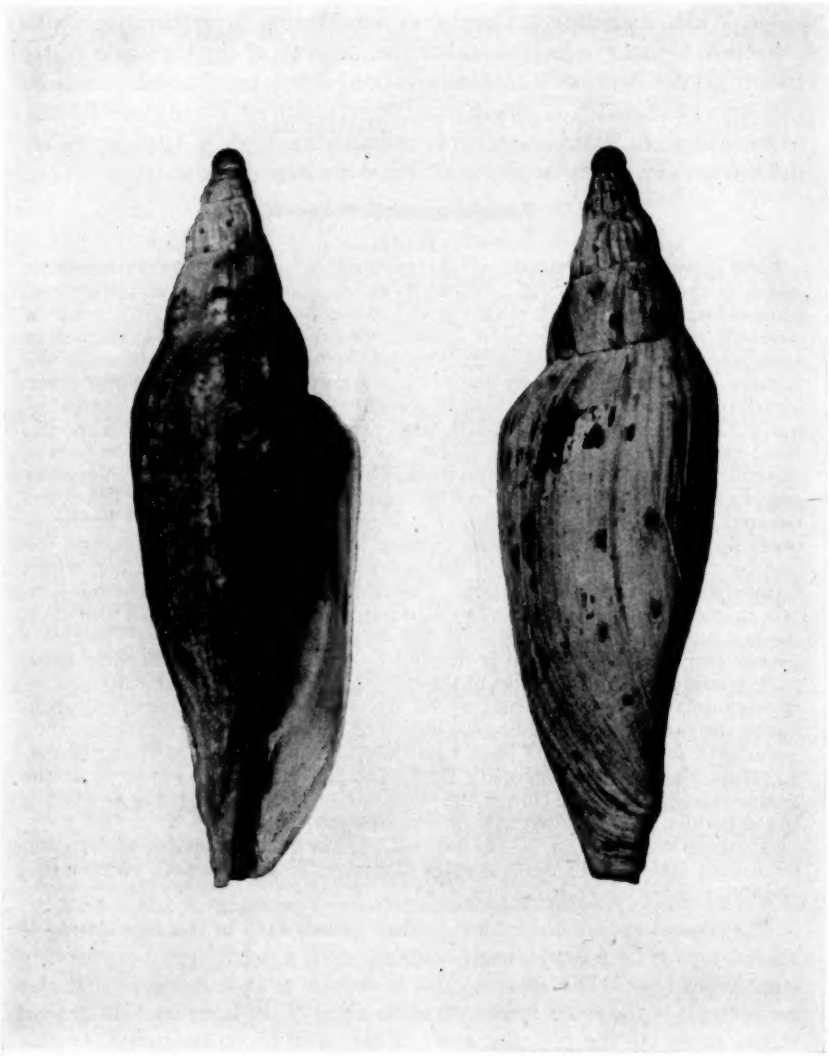

Figure 1. *Aurinia schmitti* Bartsch.

INDEX TO VOLUME 21

An * denotes the abstract of a paper before the ACADEMY or an affiliated society

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

Anthropological Society of Washington. Proceedings: 152, 237, 342.
Biological Society of Washington. Proceedings: 94, 445.
Botanical Society of Washington. Proceedings: 100, 128, 153, 372.
Entomological Society of Washington. Proceedings: 171.
Geological Society of Washington. Proceedings: 26, 178, 365, 488.
Philosophical Society of Washington. Proceedings: 42, 54, 86, 168, 276.
Washington Academy of Sciences: Proceedings: 24, 52, 167, 441, 483.

AUTHOR INDEX

ADAMS, L. H. The cubic compressibility of certain substances. 381.

—— The influence of pressure on the solubility of sodium chloride in water. A new method for the measurement of the solubilities of electrolytes under pressure. 183.

—— *The volume change of rubber under pressure. 43.

ALICATA, JOSEPH E. A *Microfilaria* from the blood of a wild rabbit. 298.

—— Resistance of rats to superinfections with a nematode, *Nippostrongylus muris*, and an apparently similar resistance of horses to superinfections with nematodes. 259.

AMES, JOSEPH, S. Certain aspects of Henry's experiments on electromagnetic induction. 493.

ASHBROOK, F. G. *Fur farming in Europe. 95.

ATWOOD, W. R. *Mid-Tertiary glacial deposits in southern France. 28.

BAILEY, VERNON. *General features of the Upper Mississippi River Wild Life and Fish Refuge. 445.

BAKER, O. E. *Changes in diet affect agriculture. 442.

BANTA, A. M. *What the crustacean tells us about evolution. 52.

BARTH, TOM F. W. The spinel structure: an example of variate atom equipoints. 255.

BARTSCH, PAUL. A new volutid marine mollusk, *Aurinia schmitti*. 529.

BARTRAM, EDWIN B. Additional Costa Rican mosses, II. 288.

BASSLER, R. S. *Indianites*, new name for the Cambrian crustacean *Indiana* Ulrich and Bassler. 364.

BEATTIE, R. KENT. *Botanical notes from Japan. 374.

BELL, W. B. *Reestablishment of musk-oxen in Alaska. 99.

BERRY, EDWARD W. A *Bothrodendron* from Bolivia. 295.

BERRY, WILLARD. Contributions to the Paleontology of Peru, V. *Nodosaria pozoensis* W. Berry, n.sp. 41 5.

BLACKMAN, M. W. A revisional study of the genus *Gnathotrichus* Eichhoff in North America. 264.

—— A revisional study of the genus *Pseudopityophthorus* Sw. in North America. 223.

BLAKE, S. F. A new *Limonium* from Haiti. 12.

—— Nine new American Asteraceae. 325.

BOECKNER, C. *The radiation from metal surfaces under low-speed electron bombardment. 279.

BORDEN, F. S. *Recent developments in the hydrographic work of the Coast and Geodetic Survey with special reference to the survey of Georges Bank. 59.

BOWIE, WILLIAM. *An outline of the organization and purpose of the Union, and Proceedings of the Section of Geodesy. 86.

BOWIE, WILLIAM. Shaping the earth. 103.

BOWMAN, PAUL W. *Pollen and peat. 374.

BRADY, M. K. *The breeding of salamanders. 451.

BROMBACHER, W. G. *Temperature coefficient of the modulus of rigidity of instrument-diaphragm and spring materials. 56.

BRYANT, H. C. *Fancy and fact in natural history. 95.

BUCHANAN, L. L. Synopsis of *Perigaster* (Coleoptera: Curculionidae). 320.

BUCHER, W. H. *The mobile belts of the earth. 489.

BUCKINGHAM, D. E. *The fish poison *Derris*. 449.

BURT, CHARLES E. A report on some amphibians and reptiles from New York and New Jersey. 198.

CANFIELD, R. H. *Internal friction in metals. 278.

CHAPIN, EDWARD A. *Adoretus luridus* Blanchard and its near relatives in the Philippine Islands. 305.

—— New species of melolonthine Scarabaeidae from the Philippine Islands. 309.

CHEVERLANGE, ELIE. *Exhibition of paintings of fishes of Tahiti. 449.

CHITWOOD, B. G. *Chondronema passali* (Leidy, 1852) n. g. (Nematoda), with notes on its life history. 356.

—— Flagellate spermatozoa in a nematode (*Trilobus longus*). 41.

CHRISLER, V. L. *The measurement of sound absorption. 277.

CHRISTIE, J. R. *Chondronema passali* (Leidy, 1852) n. g. (Nematoda), with notes on its life history. 356.

CLARK, AUSTIN H. *Notes on the behavior and migration of the milkweed butterfly. 171.

COCHRAN, DORIS M. A new lizard (*Anolis pinchoti*) from Old Providence Island. 354.

—— New Bahaman reptiles. 39.

COLLINS, HENRY B., JR. *Archeological explorations on St. Lawrence Island, Alaska. 237.

COOK, HAROLD S. The antiquity of man as indicated at Frederick, Oklahoma: A reply. 161.

COOKE, C. WYTHE. *Radial calcite concretions in marine beds in Georgia. 27.

—— Seven coastal terraces in the southeastern States. 503.

—— Why the Mayan cities of the Petén District, Guatemala, were abandoned. 283.

COOPER, G. A. Concerning the authorship of the "Preliminary notice of the lamellibranch shells of the upper Helderberg, Hamilton, and Chemung groups, etc., part 2." 459.

CUSHMAN, R. A. Three new Braconidae parasitic on bark beetles. 301.

DANE, C. H. *Uncompahgre Plateau and related structural features. 28.

DAVIES, F. T. *Aurora australis observed on the Byrd Antarctic Expedition. 280.

DAVIS, H. S. *Progress in experimental fish culture. 450.

DAVIS, WATSON. *Recent biological literature. 94.

DAY, A. L. *Borehole investigations in the geyser basin of Yellowstone National Park. 488.

DE SITTER, WILLEM. *The origin of the planetary system. 483.

DIAMOND, H. *Radio aids to air navigation. 43.

DITMARS, R. L. *Motion-picture studies of reptiles. 447.

DRECHSLER, C. A crown-rot of hollyhocks caused by *Phytophthora megasperma* n.sp. 513.

DRYDEN, A. L. Calvert (Miocene) tilting of the Maryland Coastal Plain. 131.

DYOTT, G. M. *Motion pictures of jungle life. 96.

ESTERBROOK, L. M. *The Inter-American Conference on Agriculture. 94.

EWING, H. E. *The distribution and host relationships of ectoparasites, with special reference to chiggers. 177.

FENNER, C. N. *Borehole investigations in the geyser basin of Yellowstone National Park. 488.

FISHER, W. S. A new longhorn beetle from Costa Rica (Coleoptera: Cerambycidae). 23.
FLEMING, J. A. *Proceedings of the section of Electricity and Magnetism. 90.
—— *Terrestrial magnetism. 44.
FOSTER, M. D. *The effect of the drought upon the quality of the water of the the Potomac River. 179.
FROST, S. W. *Animal life on Barro Colorado Island. 173.
GAHAN, A. B. On certain hymenopterous parasites of stored-grain insects. 213.
—— Two new hymenopterous parasites of *Tachypterellus consors* Dietz. 37.
GARNER, C. L. *An outline of the expanded program of geodetic work of the Coast and Geodetic Survey. 56.
GIBSON, R. E. The cubic compressiblity of certain substances. 381.
—— *The volume change of rubber under pressure. 43.
GILLULY, JAMES. *Heavy-mineral assemblages in some plutonic rocks from eastern Oregon. 370.
GIRTY, GEORGE H. New Carboniferous invertebrates. 390.
GISH, O. H. *Atmospheric electricity. 47.
GOLDMAN, E. A. A new agouti from Costa Rica. 481.
—— A new kinkajou from Mexico. 482.
—— New pocket gophers from Arizona and Utah. 416.
—— Six white-footed mice (*Peromyscus maniculatus* group) from islands off the Pacific Coast. 530.
—— Three new pumas. 209.
—— Two new desert foxes. 249.
GOLDMAN, M. I. *Some biologic effects of the drought in tributaries of Chesapeake Bay. 180.
GRAHAM, H. W. *Biology and chemistry. 46.
GRIFFITHS, DAVID. *How we make more bulbs. 101.
GRIGGS, R. F. *Five thousand miles for a liverwort. 373.
HALL, R. E. The influence of pressure on the solubility of sodium chloride in water. A new method for the measurement of the solubilities of electrolytes under pressure. 183.
HAMBLETON, J. I. *The behavior of the honeybee. 95.
HANSON, MALCOM P. *Radio with the Byrd Antartic Expedition. 168
HECK, N. H. *Proceedings of the Section of Seismology. 88.
—— *Some recent developments in the field of seismology. 367.
HENDERSON-SMITH, J. *Cytological studies of mosaic of tobacco. 375.
HEYL, P. R. *A report on the redetermination of the constant of gravitation. 170.
—— *The place of reason in nature. 55.
HITCHCOCK, A. S. *A botanical trip to South and East Africa. 102.
—— *Nomenclature at the International Botanical Congress. 94.
—— *The sessions on nomenclature. 153.
HITCHCOCK, MARGARET R. The mastodon of Thomas Jefferson. 80.
HOFFMAN, W. A. *A consideration of educational, especially biological, progress in China, prefaced by some general remarks on the country and its people. 451.
HORTON, A. H. *The Potomac River and the drought of 1930. 178.
HOWELL, A. H. *Exhibition of paintings of Florida birds. 445.
HUBBARD, B. R. *Geologic features of Aniakchak and Veniaminof craters, Alaska. 29.
HUMPHREY, H. B. *Influence of vegetation on stream flow during the drought. 179.
—— *Regeneration in some conifers. 128.
—— *The relation of trees and other vegetation to stream flow. 450.
—— *The relation of weather to the development of stem rust *Puccinia graminis*. 129.
HULBURT, E. O. *The zodiacal light. 276.

JOHNSTONE-WALLACE, D. B. *Competition as a factor in the success of grass and clover mixtures. 154.

JUDSON, L. V. *New instruments and methods in length measurements of high precision. 55.

KEARNEY, THOMAS H. *Cotton from a botanist's point of view. 154.

—— Plants new to Arizona. (An annotated list of species added to the recorded flora of the State or otherwise interesting.) 63.

KELLUM, L. B. Revision of the names of three fossils from the Castle Hayne and Trent marls in North Carolina. 51.

KENG, Y. L. New grasses from China. 155.

—— The genus *Chikusichloa* of Japan and China. 526.

KEULEGAN, G. H. *Measurement of the elastic hysteresis by means of tuning forks. 55.

KILLIP, ELLSWORTH P. New plants mainly from western South America—III. 347.

—— The genus *Lozanella*. 336.

KIMBALL, H. H. *Proceedings of the Section of Meterology. 88.

KING, PHILIP B. *Geology of the Marathon District, Texas. 365.

LAMBERT, E. B. *Studies on the relation of temperature to the growth, parasitism, thermal death points, and control of *Mycogene perniciosa*. 100.

LELACHEUR, EMBERT A. Tidal phenomena in Long Island Sound. 239.

LEONARD, E. C. The genus *Mendoncia* in Peru. 144.

LITTLEHALES, G. W. *Proceedings of the Section of Oceanography. 92.

LOTKA, ALFRED J. Some elementary properties of moments-of-frequency distributions. 17.

—— The extinction of families. I. 377,

—— The extinction of families. II. 453.

LOUGHLIN, G. F. *Geology of Leadville and vicinity, a review of old and recent studies. 370.

LUCAS, C. R. *Commercial fish farming in the United States. 450.

LUCKER, JOHN T. Resistance of rats to superinfections with a nematode, *Nippostrongylus muris*, and an apparently similar resistance of horses to superinfections with nematodes. 259.

MANN, WM. M. A new ant from Porto Rico. 440.

MARSH, C. DWIGHT. On a collection of Copepoda made in El Salvador by Samuel F. Hildebrand and Fred J. Foster of the U. S. Bureau of Fisheries. 207.

—— The copepod genera *Broteas* Lovén, *Paradiaptomus* Sars, *Lovenula* Methuen, and *Adiaptomus* Cooper. 397.

MATLACK, M. B. The juice sac of the orange with some observations on the plastids of citrus. 437.

MERRIAM, JOHN C. *The unity of nature as illustrated by the Grand Canyon. 441.

MERRILL, E. D. *Plants and animals of the Philippines and neighboring islands—How they came to be where they are. 443.

MOHLER, F. L. *The radiation from metal surfaces under low-speed electron bombardment. 279.

MORTON, C. V. The genus *Lozanella*. 336.

—— Notes on yagé, a drug plant of southeastern Columbia. 485.

NELSON, E. W. A new kinkajou from Mexico. 482.

—— Six new white-footed mice (*Peromyscus maniculatus* group) from islands off the Pacific Coast. 530.

—— Three new pumas. 209.

NESBIT, R. A. *Biological aspects of conservation of marine fishery resources, New York and New Jersey. 99.

NUTTING, P. G. Adsorption and base exchange. 33.

OMAN, P. W. New Jassinae, with notes on other species. 430.

PAUL, J. H. *Meterology. 46.

PEARSON, T. GILBERT. *Adventures in bird protection. 446.

PERRIER, GEORGES. Raoul Gautier. 340.

PETERS, M. F. *An investigation of the effectiveness and reliability of electric sparks in automotive ignition. 56.

PIERCE, W. D. *The mango weevils. 176.
PIPER, A. M. *Observations in The Dalles region, Oregon, bearing on the history of the Columbia River. 371.
PITTIER, H. *Berberis* in Venezuela, new species of *Oxalis*, *Exogonium*, and others. 134.
POSNJAK, E. The spinel structure: An example of variate atom equipoints. 255.
PRICE, EMMETT, W. *Metagonimoides oregonensis*, a new trematode from a racoon. 405.
PRYTHERCH, H. F. *Spawning, setting and development of the oyster. 98.
RATHBUN, MARY J. A new species of Pinnotherid crab from Costa Rica. 262.
—— New crabs from the Gulf of Mexico. 125.
REED, J. C. *Heavy-mineral assemblages in some plutonic rocks from eastern Oregon. 370.
RICHARDSON, L. T. The heat of solution of some potash minerals. 243.
ROHWER, S. A. *Remarks on the present status of some insect pests which are subject to federal quarantine. 172.
ROONEY, W. J. *Earth-resistivity survey at Huancayo, Peru, and relation of resistivity to earth-current potential records. 42.
ROSS, C. P. *The physiography of south-central Idaho. 369.
RUBEY, W. W. *The Illinois River, a problem in channel equilibrium. 366.
SCHMITT, W. L. *Exhibition of a rare isopod. 95.
SCHULTZ, ADOLPH H. *Man's place among the primates. 24.
SCHULTZ, E. S. *Virus diseases of potatoes. 375.
SCHWARTZ, BENJAMIN. A *Microfilaria* from the blood of a wild rabbit. 298.
—— Resistance of rats to superinfections with a nematode, *Nippostrongylus muris*, and an apparently similar resistance of horses to superinfections with nematodes. 259.
SCOFIELD, C. S. *The effect of boron on citrus in California. 100.
SCRIVENER, J. W. Notes on *Gypona octolineata* (Say). 222.
SEEGER, R. J. The quantum theory of Born and Wiener. 315.
SETZLER, FRANK M. *The Mound-Builder cultures of the Upper Mississippi Valley. 342.
SHAMEL, H. HAROLD. *Akodon chacoensis*, a new cricetine rodent from Argentina. 427.
—— Bats from the Bahamas. 251.
SHEAR, C. L. *The fungus foray. 153.
SHENON, P. J. *The Flathead Mine, Montana, an unusual silver deposit. 181.
SMITH, H. M. *Some new and curious Siamese fishes. 96.
SNYDER, W. F. *The measurement of sound absorption. 277.
SOULE, F. N. *Oceanography. 46.
SPENCER, J. W. *Observations on Colorado elk herds. 95.
SPUNAR, VAL. MAR. On Fermat's Last Theorem. 21.
STEINER, G. *Neotylenchus abulbosus* n. g., n. sp. (*Tylenchidae*, *Nematoda*) the causal agent of a new nematosis of various crop plants. 536.
—— On the status of the nemic genera *Aphelenchus* Bastain, *Pathoaphelenchus* Cobb, *Paraphelenchus* Micoletzky, *Parasitaphelenchus* Fuchs, *Isonchus* Cobb and *Seinura* Fuchs. 468.
STEVENS, R. E. Further studies of kolm. 409.
STEVENSON, F. J. *Genetics in relation to potato breeding. 375.
STILES, C. W. *Is international zoological nomenclature practicable? Report on Padua Congress. 97.
SWALLEN, JASON R. Five new grasses from Colombia. 14.
—— Two new grasses from Mexico. 436.
SWANTON, JOHN R. The Caddo social organization and its possible historical significance. 203.
TARBETT, R. E. *Control over mosquito breeding. 449.
TEICHERT, CURT. Recent German theories about structural geology. 1.
TERHUNE, H. W. *Wild-life protection in Alaska. 447.

TOWNSEND, C. H. *A recent expedition to the Galapagos Islands and studies of the Galapagos tortoises. 448.

TUVE, M. A. *Artificial radium rays from high-voltage tubes. 167.

UHLER, F. M. *Waterfowl and reptile life of the Upper Mississippi River Wild Life and Fish Refuge. 445.

ULRICH, E. O. *Highlights of the past two seasons' work. I. Origin and stratigraphic horizon of the zinc ores of the Mascot District of East Tennessee. 30.

—— *Indianites*, new name for the Cambrian crustacean *Indiana* Ulrich and Bassler. 364.

WALKER, E. H. Four new species of Myrsinaceae from China. 477.

WALKER, W. M. *Archeological reconnaissance in the Hawaiian Islands. 343.

WARD, MELBOURNE. *Natural history of the Barrier Reef of Australia. 96.

—— *Wanderings in North Australia. 97.

WATTS, C. B. *The transit instrument and the synchronous motor. 43.

WELLS, R. C. Further studies of kolm. 409.

—— The heat of solution of some potash minerals. 243.

—— *Van't Hoff's studies of minerals deposited from sea water. 372.

WENNER, F. *Impressions of the excursions and entertainments. 93.

WENSEL, H. T. *The Waidner-Burgess standard of light and the freezing point of platinum. 276.

WETMORE, ALEXANDER. *The International Ornithological Congress. 94

WHERRY, EDGAR T. A new spiral-orchid from the Southern States. 49.

—— The eastern short-stemmed leather flowers. 194.

WRIGHT, F. E. *Optical methods for reducing the effects of photographic-plate grain. 279.

ZIES, E. G. *The geologist and analyst—a study in cooperation. 26.

SUBJECT INDEX

Anthropology. *Man's place among the primates. ADOLPH H. SCHULTZ. 24.
The antiquity of man as indicated at Frederick, Oklahoma: a reply. HAROLD S. COOK. 161.
Archeology. *Archeological explorations on St. Lawrence Island, Alaska. HENRY B. COLLINS, JR. 237.
*Archeological reconnaissance in the Hawaiian Islands. W. M. WALKER. 343.
*The Mound-Builder cultures of the Upper Mississippi Valley. FRANK M. SETZLER. 342.
Why the Mayan cities of the Petén District, Guatemala, were abandoned. C. WYTHE COOKE. 283.
Astronomy. *The origin of the planetary system. WILLEM DE SITTER. 483.
*The transit instrument and the synchronous motor. C. B. WATTS. 43.
Biogeography. *Plants and animals of the Philippines and neighboring islands—How they came to be where they are. E. D. MERRILL. 443.
Biology. *Biological aspects of conservation of marine fishery resources, New York and New Jersey. R. A. NESBIT. 99.
*Biology and chemistry. H. W. GRAHAM. 46.
*Fancy and fact in natural history. H. C. BRYANT. 95.
*Motion pictures of jungle life. G. M. DYOTT. 96.
*Natural history of the Barrier Reef of Australia. MELBOURNE WARD. 96.
*Recent biological literature. WATSON DAVIS. 94.
*Wanderings in North Australia. MELBOURNE WARD. 97.
Botany. *A botanical trip to South and East Africa. A. S. HITCHCOCK. 102.
A crown-rot of hollyhocks caused by *Phytophthora megasperma* n. sp. C. DRECHSLER. 513.
Additional Costa Rican mosses, II. EDWIN B. BARTRAM. 288.
A new *Limonium* from Haiti. S. F. BLAKE. 12.
A new spiral-orchid from the Southern States. EDGAR T. WHERRY. 49.
Berberis in Venezuela, new species of *Oxalis*, *Exogonium*, and others. H. PITTIER. 134.
*Botanical notes from Japan. R. KENT BEATTIE. 374.
*Competition as a factor in the success of grass and clover mixtures. D. B. JOHNSTONE-WALLACE. 154.
*Cotton from a botanist's point of view. THOMAS H. KEARNEY. 154.
*Cytological studies of mosaic of tobacco. J. HENDERSON-SMITH. 375
Four new species of Myrsinaceae from China. E. H. WALKER. 477.
Five new grasses from Colombia. JASON R. SWALLEN. 14.
*Genetics in relation to potato breeding. F. J. STEVENSON. 375.
*How do we make more bulbs? DAVID GRIFFITHS. 101.
New grasses from China. Y. L. KENG. 155.
New plants mainly from western South America—III. ELLSWORTH P. KILLIP. 347.
Nine new American Asteraceae. S. F. BLAKE. 325.
*Nomenclature at the International Botanical Congress. A. S. HITCHCOCK. 94.
Notes on yagé, a drug plant of southeastern Columbia. C. V. MORTON. 485.
Plants new to Arizona. THOMAS H. KEARNEY. 63.

*Pollen and peat. PAUL W. BOWMAN. 374.
*Regeneration in some conifers. H. B. HUMPHREY. 128.
*Reports on the Botanical Congress at London. BOTANICAL SOCIETY. 153.
*Studies on the relation of temperature to the growth, parasitism, thermal death points, and control of *Mycogone perniciosa*. E. B. LAMBERT. 100.
The eastern short-stemmed leather flowers. EDGAR T. WHERRY. 194.
*The effect of boron on citrus in California. C. S. SCOFIELD. 100.
*The fungus foray. C. L. SHEAR. 153.
The genus *Chikusichloa* of Japan and China. Y. L. KENG. 526.
The genus *Lozanella*. E. P. KILLIP and C. V. MORTON. 336.
The genus *Mendoncia* in Peru. E. C. LEONARD. 144.
*The Inter-American Conference on Agriculture. L. M. ESTERBROOKE. 94.
The juice sac of the orange with some observations on the plastids of citrus. M. B. MATLACK. 437.
*The relation of weather to the development of stem rust *Puccinia graminis*. H. B. HUMPHREY. 129.
*The sessions on nomenclature. A. S. HITCHCOCK. 153.
Two new grasses from Mexico. JASON R. SWALLEN. 436.
*Virus diseases of potatoes. E. S. SCHULTZ. 375.
Chemistry. Further studies of kolm. R. C. WELLS and R. E. STEVENS. 409.
Crystallography. The spinel structure: An example of variate atom equipoints. TOM F. W. BARTH and E. POSNJAK. 255.
Economics. *Changes in diet affect agriculture. O. E. BAKER. 442.
Entomology. *Adoretus luridus* Blanchard and its near relatives in the Philippine Islands. EDWARD A. CHAPIN. 305.
A new ant from Porto Rico. WM. M. MANN. 440.
A new longhorn beetle from Costa Rica (Coleoptera: Cerambycidae). W. S. FISHER. 23.
A revisional study of the genus *Gnathotrichus* Eichhoff in North America. M. W. BLACKMAN. 264.
A revisional study of the genus *Pseudopityophthorus* Sw. in North America. M. W. BLACKMAN. 223.
*Control over mosquito breeding. R. E. TARBETT. 449.
New Jassinae, with notes on other species. P. W. OMAN. 430.
New species of melolonthine Scarabaeidae from the Philippine Islands. EDWARD A. CHAPIN. 309.
Notes on *Gypona octolineata* (Say). J. W. SCRIVENER. 222.
*Notes on the behavior and migration of the milkweed butterfly. AUSTIN H. CLARK. 171.
On certain hymenopterous parasites of stored-grain insects. A. B. GAHAN. 213.
*Remarks on the present status of some insect pests which are subject to federal quarantine. S. A. ROHWER. 172.
Synopsis of *Perigaster* (Coleoptera: Curculionidae). L. L. BUCHANAN. 320.
*The behavior of the honeybee. J. I. HAMBLETON. 95.
*The distribution and host relationships of ectoparasites, with special reference to chiggers. H. E. EWING. 177.
*The mango weevils. W. D. PIERCE. 176.
Three new Braconidae parasitic on bark beetles. R. A. CUSHMAN. 301.
Two new hymenopterous parasites of *Tachypterellus consors* Dietz. A. B. GAHAN. 37.
Ethnology. The Caddo social organization and its possible historical significance. JOHN R. SWANTON. 203.
Evolution. *What the crustacean tells us about evolution. A. M. BANTA. 52.
Geodesy. *An outline of the expanded program of geodetic work of the Coast

and Geodetic Survey. C. L. GARNER. 56.
*An outline of the organization and purpose of the Union, and Proceedings of the Section of Geodesy. WILLIAM BOWIE. 86.
Geology. *Borehole investigations in the geyser basin of Yellowstone National Park. C. N. FENNER and A. L. DAY. 488.
Calvert (Miocene) tilting of the Maryland Coastal Plain. A. L. DRYDEN, JR. 131.
*Geologic features of Aniakchak and Veniaminof craters, Alaska. B. R. HUBBARD. 29.
*Geology of Leadville and vicinity, a review of old and recent studies. G. F. LOUGHLIN. 370.
*Geology of the Marathon District, Texas. PHILIP B. KING. 365.
*Heavy-mineral assemblages in some plutonic rocks from eastern Oregon. J. C. REED AND JAMES GILLULY. 370.
*Mid-Tertiary glacial deposits in southern France. W. R. ATWOOD. 28.
*Origin and stratigraphic horizon of the zinc ores of the Mascot District of East Tennessee. E. O. ULRICH. 30.
*Radial calcite concretions in marine beds in Georgia. C. WYTHE COOKE. 27.
Recent German theories about structural geology. CURT TEICHERT. 1.
Seven coastal terraces in the southeastern States. C. WYTHE COOKE. 503.
The antiquity of man as indicated at Frederick, Oklahoma: A reply. HAROLD S. COOK. 161.
*The Flathead Mine, Montana, an unusual silver deposit. P. J. SHENON. 181.
*The geologist and analyst—a study in cooperation. E. G. ZIES. 26.
*The Illinois River, a problem in channel equilibrium. W. W. RUBEY. 366.
*The mobile belts of the earth. W. H. BUCHER.
*Uncompahgre Plateau and related structural features. C. H. DANE. 28.
Geophysics. *A report on the redetermination of the constant of gravitation. P. R. HEYL. 170.
*Atmospheric electricity. O. H. GISH. 47.
*Earth-resistivity survey at Huancayo, Peru, and relation of resistivity to earth-current potential records. W. J. ROONEY. 42.
*Impressions of the excursions and entertainments. F. WENNER. 93.
*Proceedings of the Section of Electricity and Magnetism. J. A. FLEMING. 90.
*Proceedings of the Section of Meteorology. H. H. KIMBALL. 88.
*Proceedings of the Section of Oceanography. G. W. LITTLEHALES. 92.
*Proceedings of the Section of Seismology. N. H. HECK. 88.
Shaping the earth. WILLIAM BOWIE. 103.
*Some recent developments in the field of seismology. N. H. HECK. 367.
*Terrestrial magnetism. J. A. FLEMING. 44.
Tidal phenomena in Long Island Sound. EMBERT A. LELACHEUR. 239.
Herpetology. A new lizard (*Anolis pinchoti*) from Old Providence Island. DORIS M. COCHRAN. 354.
*A recent expedition to the Galapagos Islands and studies of the Galapagos tortoises. C. H. TOWNSEND. 448.
A report on some amphibians and reptiles from New York and New Jersey. CHARLES E. BURT. 198.
*Motion-picture studies of reptiles. R. L. DITMARS. 447.
New Bahama reptiles. DORIS M. COCHRAN. 39.
*The breeding of salamanders. M. K. BRADY. 451.
*Waterfowl and reptile life of the Upper Mississippi River Wild Life and Fish Refuge. F. M. UHLER. 445.
Hydrology. *Influence of vegetation on stream flow during the drought. H. B. HUMPHREY. 179.
*Some biologic effects of the drought in tributaries of Chesapeake Bay. M. I. GOLDMAN. 180.

*The effect of the drought upon the quality of the water of the Potomac River. M. D. FOSTER. 179.
*The Potomac River and the drought of 1930. A. H. HORTON. 178.
*The relation of trees and other vegetation to stream flow. H. B. HUMPHREY. 450.
Ichthyology. *Commercial fish farming in the United States. C. R. LUCAS. 450.
*Exhibition of paintings of fishes from Tahiti. ELIE CHEVERLANGE. 449.
*Progress in experimental fish culture. H. S. DAVIS. 450.
*Some new and curious Siamese fishes. H. M. SMITH. 96.
Mammalogy. *Akodon chacoensis*, a new cricetine rodent from Argentina. H. HAROLD SHAMEL. 427.
A new agouti. from Costa Rica. E. A. GOLDMAN. 481.
A new kinkajou from Mexico. E. W. NELSON and E. A. GOLDMAN. 482.
Bats from the Bahamas. H. HAROLD SHAMEL. 251.
*Fur farming in Europe. F. G. ASHBROOK. 95.
New pocket gophers from Arizona and Utah. E. A. GOLDMAN. 416.
*Observations on Colorado elk herds. J. W. SPENCER. 95.
*Reestablishment of muskoxen in Alaska. W. B. BELL. 99.
Three new pumas. E. W. NELSON and E. A. GOLDMAN. 209.
Two new desert foxes. E. A. GOLDMAN. 249.
Six new white-footed mice (*Peromyscus maniculatus* group) from islands off the pacific Coast. E. W. NELSON and E. A. GOLDMAN. 530.
Mathematics. On Fermat's Last Theorem III. VAL. MAR. SPUNAR. 21.
The quantum theory of Born and Wiener. R. J. SEEGER. 315.
Meteorology. *Aurora australiso bserved on the Byrd Antartic Expedition. F. T. DAVIES. 280.
*Meteorology. J. H. PAUL. 46.
*The zodiacal light. E. O. HULBURT. 276.
Miscellaneous. *A consideration of educational, especially biological, progress in China, prefaced by some general remarks on the country and its people. W. A. HOFFMAN. 451.
*Five thousand miles for a liverwort. R. F. GRIGGS. 373.
*General features of the Upper Mississippi River Wild Life and Fish Refuge. VERNON BAILEY. 445.
*The fish poison *Derris*. D. E. BUCKINGHAM. 449.
*The Joseph Henry lectureship. 344.
*The place of reason in nature. PAUL R. HEYL. 55.
*The unity of nature as illustrated by the Grand Canyon. JOHN C. MERRIAM. 441.
*Wild-life protection in Alaska. H. W. TERHUNE. 447.
Necrology. ACHESON, EDWARD GOODRICH. 346.
AINSLIE, GEORGE GOODING. 48.
CLARKE, FRANK WIGGLESWORTH. 346.
FARRINGTON, ARTHUR M. 376.
GAUTIER, RAOUL. 282, 340.
GIDLEY, JAMES WILLIAMS. 476.
HODGKINS, HOWARD LINCOLN. 130.
OAKLEY, RUSSELL ARTHUR. 376.
PAUL, HENRY MARTYN. 182.
PRITCHARD, FREDERICK J. 48.
SPILLMAN, WILLIAM JASPER. 346.
Oceanography. *Oceanography. F. N. SOULE. 46.
*Recent developments in the hydrographic work of the Coast and Geodetic Survey with special reference to the survey of Georges Bank. F. S. BORDEN. 59.
Ornithology. *Adventures in bird protection. T. GILBERT PEARSON. 446.
*Exhibition of paintings of Florida birds A. H. HOWELL. 445.
*The International Ornithological Congress. ALEXANDER WETMORE. 94.
*Waterfowl and reptile life of the Upper Mississippi River Wild Life and Fish Refuge. F. M. UHLER. 445.
Paleobotany. A *Bothrodendron* from Bolivia. EDWARD W. BERRY. 295.

Paleontology. Concerning the authorship of the *Preliminary notice of the lamellibranch shells of the upper Helderberg, Hamilton, and Chemung groups, etc., part 2.* G. A. COOPER. 459.

Nodosaria pozoensis W. Berry, n. sp. WILLARD BERRY. 415.

Indianites, new name for the Cambrian crustacean *Indiana* Ulrich and Bassler E. O. ULRICH and R. S. BASSLER. 364.

New Carboniferous invertebrates—III. GEORGE H. GIRTY. 390.

Revision of the names of three fossils from the Castle Hayne and Trent marls in North Carolina. L. B. KELLUM. 51.

The mastodon of Thomas Jefferson. MARGARET R. HITCHCOCK. 80.

Physical chemistry. Adsorption and base exchange. P. G. NUTTING. 33.

The heat of solution of some potash minerals. L. T. RICHARDSON and R. C. WELLS. 243.

The influence of pressure on the solubility of sodium chloride in water. A new method for the measurement of the solubilities of electrolytes under pressure. L. H. ADAMS and R. E. HALL. 183.

*Van't Hoff's studies of minerals deposited from sea water. R. C. WELLS. 372.

Physiography. *Observations in The Dalles region, Oregon, bearing on the history of the Columbia River. A. M. PIPER. 371.

*The physiography of south-central Idaho. C. P. ROSS. 369.

Why the Mayan cities of the Petén District, Guatemala, were abandoned. C. WYTHE COOKE. 283.

Physics. *Atmospheric electricity. O. H GISH. 47.

*An investigation of the effectiveness and reliability of electric sparks in automotive ignition. M. F. PETERS. 56.

*Artificial radium rays from high-voltage tubes. M. A. TUVE. 167.

Certain aspects of Henry's experiments on electromagnetic induction. JOSEPH S. AMES. 493.

*Internal friction in metals. R. H. CANFIELD. 278.

*Measurement of the elastic hysteresis by means of tuning forks. G. H. KEULEGAN. 55.

*New instruments and methods in length measurements of high precision L. V. JUDSON. 55.

*Optical methods for reducing the effects of photographic-plate grain. F. E. WRIGHT. 279.

*Radio aids to air navigation. H. DIAMOND. 43.

*Radio with the Byrd Antarctic Expedition. MALCOLM P. HANSOM. 168.

*Temperature coefficient of the modulus of rigidity of instrument-diaphragm and spring materials. W. G. BROMBACHER. 56.

The cubic compressibility of certain substances. L. H. ADAMS and R. E. GIBSON. 381.

*The measurement of sound absorption. V. L. CHRISLER and W. F. SNYDER. 277.

The quantum theory of Born and Wiener. R. J. SEEGER. 315.

*The radiation from metal surfaces under low-speed electron bombardment. F. L. MOHLER and C. BOECKNER. 279.

*The volume change of rubber under pressure. R. E. GIBSON and L. H. ADAMS. 43.

*The Waidner-Burgess standard of light and the freezing point of platinum. H. T. WENSEL. 276.

Population analysis. The extinction of families. I. ALFRED J. LOTKA. 377.

The extinction of families. II. 453.

Scientific notes and news. 32, 47, 61, 154, 182, 206, 237, 253, 314, 344, 375, 407, 451, 475, 491.

Statistics. Some elementary properties of moments-of-frequency distributions. A. J. LOTKA. 17.

Zoology. A *Microfilaria* from the blood of a wild rabbit. BENJAMIN SCHWARTZ and JOSEPH E. ALICATA. 298.

A new marine mollusk, *Aurinia schmitti*. PAUL BARTSCH. 539.

A new species of Pinnotherid crab from Costa Rica. MARY J. RATHBUN. 262.

Animal life on Barro Colorado Island. S. W. FROST. 173.

Chondronema passali (Leidy, 1852) n. g. (Nematoda), with notes on its life history. J. R. CHRISTIE and B. G. CHITWOOD. 356.

Copepoda from El Salvador. C. DWIGHT MARSH. 207.

*Exhibition of a rare isopod. W. L. SCHMITT. 95.

Flagellate spermatozoa in a nematode (*Trilobus longus*). B. G. CHITWOOD. 41.

*Is international zoological nomenclature practicable? Report on Padua Congress. C. W. STILES. 97.

Metagonimoides oregonensis, a new trematode from a raccoon. EMMETT W. PRICE. 405.

Neotylenchus albulbosus n. g., n. sp. (Tylenchidae, Nematoda) the causal agent of a new nematosis of various crop plants. G. STEINER. 536.

New crabs from the Gulf of Mexico. MARY J. RATHBUN. 125.

On the status of the nemic genera *Aphelenchus* Bastain, *Pathoaphelenchus* Cobb, *Paraphelenchus* Micoletzky *Parasitaphelenchus* Fuchs, *Isonchus* Cobb and *Seinura* Fuchs. G. STEINER. 468.

Resistance of rats to superinfections with a nematode, *Nippostrongylus muris*, and an apparently similar resistance of horses to superinfections with nematodes. BENJAMIN SCHWARTZ, JOSEPH E. ALICATA, and JOHN T. LUCKER. 259.

*Spawning, setting and development of the oyster. H. F. PRYTHERCH. 98.

The copepod genera *Broteas* Lovén, *Paradiaptomus* Sars, *Lovenula* Schmeil, *Metadiaptomus* Methuen, and *Adiaptomus* Cooper. C. DWIGHT MARSH. 397.